PRACTICAL ASTRONOMY.

PRACTICAL
ASTRONOMY:

CONTAINING

A DESCRIPTION OF THE SOLAR SYSTEM;

THE DOCTRINE OF THE SPHERE;

THE PRINCIPAL PROBLEMS IN ASTRONOMY,

Illustrated with many EXAMPLES.

TOGETHER WITH

ASTRONOMICAL TABLES

OF THE

SUN, MOON, AND PRIMARY PLANETS.

By ALEXANDER EWING,

TEACHER OF MATHEMATICS, *EDINBURGH.*

EDINBURGH:

PRINTED FOR PETER HILL, EDINBURGH;

AND T. N. LONGMAN, LONDON.

1797.

Entered in Stationers Hall.

PREFACE.

OF all the ſciences, ASTRONOMY may be reckoned the moſt ſublime. The vaſt magnitudes, diſtances, and velocities of the ſubjects of which it treats, ſeem to ſet them beyond human powers; and yet the knowledge of theſe is, in ſome caſes, neceſſary for conducting the buſineſs of life.

The knowledge of aſtronomy enables men to explore the figure and magnitude of the earth; to aſcertain the poſitions of places on its ſurface; to form an intercourſe between the moſt diſtant nations, and teach them to ſupply each others wants; and thus all the inhabitants of the earth become partakers of its general produce.

Although great diſcoveries and improvements have been lately made in Aſtronomy, the ſcience is ſtill poſſeſſed by a ſmall number of perſons; and there is much wanting to render the ſtudy univerſal. To make the moſt of any art or ſcience for the benefit of mankind, it is neceſſary that many perſons underſtand it; for the united ſtrength of numbers will eaſily perform what exceeds the ability of a few. If we can find means to increaſe the number of ſtudents by inducing many to learn Aſtronomy, the advantages which may be expected will be great and important: and however diſtant the proſpect, there is no reaſon to deſpair of ſucceſs. The time may come when Aſtronomy will be as generally ſtudied as the more common parts of education are at preſent. About 400 years ago there were fewer good accountants in Britain than there are aſtronomers at this day; and why may not the knowledge of the ſtars become as common as the application of arithmetic to the affairs of life? Let us open the door, and point out the road, and there will be no want of perſons to occupy it.

One cauſe of the preſent ſmall number of aſtronomers is,

that the ſcience has been generally cultivated by eminent mathematicians; and hence an ill-founded opinion has ariſen, that none could learn Aſtronomy without previouſly ſtudying a tedious courſe of mathematics. This opinion has deterred many from venturing to begin a ſtudy, the want of which they have felt ſeverely when, in future life, they were engaged in buſineſs wherein that ſcience was neceſſary.

Another cauſe is, the want of books on the ſubject accommodated to beginners. Some of the beſt we have were written, during the laſt century, by Gregory, Keill, Whiſton, and other great men; conſiſting for the moſt part of lectures, very valuable indeed, but improper for ſchool-books, which ſhould contain ſhort and plain definitions, precepts, and illuſtrations, ſuited to the circumſtances of learners. There is alſo a very great ſcarcity of Aſtronomical Tables agreeable to the preſent improved ſtate of the ſcience. The Tables in common uſe before the year 1760 were adapted to the Julian ſtyle, which, beſides their other defects, renders them inconvenient for preſent uſe.

It may ſeem paradoxical to affirm, although it is ſtrictly true, that the diſcoveries and improvements made in Aſtronomy during the laſt 40 years, inſtead of promoting the ſtudy, have had a contrary effect. This cannot be imputed to the improvements, but to the partial reformation of Aſtronomical Tables. Mr Mayer's Solar and Lunar Tables excelled the old ones ſo far, that they put them out of uſe; and as we had no Tables of the primary planets on the ſame plan, there was a neceſſity to uſe the old Tables for computing their places: and the method of calculation by the new and old being very different, produced a confuſion which was diſcouraging to learners, and troubleſome to all.

To remove as much as poſſible every impediment, and open an

an eaſy acceſs to the ſtudy of Aſtronomy, this Work is offered to the Public. It was undertaken with the deſign of aſſiſting ſtudents who have no other previous qualification except the knowledge of arithmetic, of the circles of the ſphere, and the uſe of logarithms. With theſe qualifications (which may be attained in a ſhort time), and the help of this Book, any perſon may learn to ſolve the problems relating to the places and poſitions of the ſun, moon, planets, and fixed ſtars, for any given time and place; either with the aſſiſtance of a teacher, or by themſelves, as they chooſe.

To accompliſh the end propoſed, Tables of the ſun, moon, and planets, have been calculated and collected, adapted to the Gregorian ſtyle, and extended farther than former Tables; and the whole has been ſo abridged and condenſed as to be comprehended in little room, that, being ſhort and cheap, it might be a proper ſchool-book, and at the ſame time afford ſufficient aſſiſtance for ſolving all the common problems in Practical Aſtronomy.

That the learner may have every needful aſſiſtance, there is prefixed to the Tables a ſhort deſcription of the Solar Syſtem as now received by aſtronomers, together with definitions of the circles of the ſphere, and of the uſual terms of Geography and Aſtronomy: a ſhort account of the fixed ſtars and conſtellations, with ſome problems relating to them; and likewiſe the kalendar, with explanations and ſolutions of the problems commonly propoſed under that head: then follows the principal part of the book, *viz.* Problems in Practical Aſtronomy, with a great variety of examples. The ſolutions of theſe problems contain precepts and directions for uſing the Tables, delivered in ſuch plain language that learners of common capacity may eaſily underſtand them. There is alſo given an explanation of the Tables, containing their conſtruction, wherein ſome things briefly mentioned

in

in other parts of the Work are more fully explaned; as alſo the conſtruction and uſe of the Table of Logiſtical Logarithms.

An attempt to introduce the ſtudy of Aſtronomy into the ſchools in the eaſieſt manner is here offered to the Public, Such as have capacity and inclination have now ſufficient help to learn the ſcience in a ſhort time. Thoſe who underſtand the value of it will approve of what is done; and with reſpect to others, arguments could be of no avail.

If any ſhall object, that ſome Tables are omitted which they expected to find in a book of this kind, ſuch will pleaſe to be informed, that the Author's deſign was not to publiſh a complete ſyſtem either of Tables or Problems, but only ſuch as are moſt generally uſeful; and which being underſtood by any learner, may enable him to proſecute the ſtudy with greater ſucceſs than he could have done without ſuch aſſiſtance. If the Book anſwers this end, the Author has effected all that he propoſed.

ADVERTISEMENT.

Lately Publiſhed (wrote by the ſame Author),

INSTITUTES OF ARITHMETIC, for the uſe of Schools, 3d Edition.

A SYNOPSIS OF PRACTICAL MATHEMATICS, 3d Edition.

(*There are only a few Copies of this Book on hand*).

CONTENTS.

INTRODUCTION - - Page 1
Description of the Solar System - 3
The Doctrine of the Sphere - - 16
The Kalendar - - - 55

PRACTICAL ASTRONOMY.

Problems.
I.—III. To reduce the time of any given place to that of another - - 79
IV. To reduce apparent time to mean time, and the contrary - - - 85
V. To calculate the Longitude of the Sun for any given time and place by the Tables 89
VI.—VIII. To find the Logarithm of the Earth's distance from the Sun, the Sun's semidiameter and hourly motion, with his R. A. 94
IX.—XII. By the Sun's R. A. to find his Longitude, and by his Longitude to find his Declination, with the angle contained between the Ecliptic and the parallel of the Sun's Declination at the time - - 97
XIII. To calculate the Longitude of the Moon by the Tables - - - 105
XIV. To calculate the Moon's Latitude - 115
XV.—XIX. To find the Moon's equatorial parallax, horizontal parallax, diameter, hourly motion, in Longitude and in Latitude 119
XX. To calculate the Moon's R. A. and Declination - - - - 124

Problems.

Problems.		Page
XXI. XXII.	To calculate the Longitude and Latitude of a Planet	129
XXIII.	The geocentric Longitude and Latitude of a Planet being given, to find its R. A. and Declination	149
XXIV.	To calculate the time when a Planet will be on the Meridian any given day	164
XXV.	To find the time when the Moon is on the Meridian	168
XXVI.	To find the time of ſun riſing and ſetting in any Latitude	176
XXVII.	To find the apparent time of ſun riſing and ſetting	182
XXVIII.	To find the apparent time of the riſing and ſetting of any fixed ſtar	185
XXIX.	To find the time of the Moon's riſing and ſetting	190
XXX.	To find the time of the mean Syzygies in any given Year and Month	199
XXXI.	To find the time of true Conjunction of the Sun and Moon	203
XXXII.	To calculate the time of new and full Moon by other Tables	208
XXXIII.	To find the number of Eclipſes in any given Year	223
XXXIV.	To calculate an Eclipſe of the Moon	228
XXXV.	To deſcribe the Earth's Diſc, and the path of a place thereon	241
XXXVI.	To calculate an Eclipſe of the Sun	244
XXXVII.	To deſcribe the figure of a Solar Eclipſe at a given place on the Earth	246
	Explanation of the Tables	247

THE

THE TABLES.

The Latitudes and Longitudes of ſome Cities and Places, with the difference of time between their Meridians and that of Greenwich, for which the Tables are calculated - - - - - Page 3
Tables of the Sun's Mean Motions, &c. - - 5
Mean Refractions, Sun's Equations, Logarithms of the Earth's diſtance from the Sun - - - 13
Sun's Declination for every degree of Longitude, Sun's Semidiameter and Hourly Motion - - 17
Equation of time to every degree of the Ecliptic, and for every day in the year - - - - 19
Reduction of the Ecliptic to the Equator - - 23
The Sun's Longitude for every day of the year - 25
——— Right Aſcenſion for ditto - - 27
Tables of the Moon's Mean Motions - - 29
——— the Moon's Equations - - 44
Tables for finding the Moon's Latitude, Parallax, Diameter, Hourly Motion, and angle of her path with the Ecliptic - - - - - 53
Tables for finding the Right Aſcenſion and Declination of the Moon, or any Zodiacal Star - - 62
Tables of the Moon's mean Motions from the Sun - 70
Table of the Mean Motions, &c. of the Planet Mercury 72
——————————— of Venus - - 82
——————————— of Mars - - 91
——————————— of Jupiter - - 101
——————————— of Saturn - - 111
Table of the Mean new Moons in March, &c. - 121
Table of Logiſtical Logarithms - - 128
Table of Sun-riſing or Seminocturnal Arcs, in lat. 56° N. 142

ERRATA.

To the BINDER.

The PLATE to face Page 249.

ERRATA.

After P. 87. the Chapters are wrong numbered.
P. 149. *for* Prob. XXII. *read* Prob. XXIII.

In the TABLES,

P. 23. head of the left hand column, *for* ′ ″ *read* ° ′.

PRACTICAL ASTRONOMY.

INTRODUCTION.

ASTRONOMY is the knowledge of the ſtars, with reſpect to their numbers, magnitudes, diſtances, motions, and appearances, as ſeen from any place of the earth.

By STAR, in aſtronomy, is underſtood any body which ſhines in the heavens, whether it emits or reflects light.

Stars which emit light are the lucid bodies in the univerſe: they appear always at the ſame diſtance from each other, and therefore are called *fixed ſtars*. The ſun, which enlightens the earth and the reſt of the planets, is one of them. His great magnitude, in compariſon of the reſt, is owing to his being nearer to the earth than they are; for if he was ſeen at the ſame diſtance, he would appear as ſmall as any other fixed ſtar.

According to this hypotheſis, the fixed ſtars, which appear to us in the night as lucid points, are large bodies, ſome of them equal to or perhaps greater than the ſun: and ſince every ſtar continues in the ſame place, it is probable that each of them affords heat and light to ſome number of opaque bodies, as the ſun does to the planets in his ſyſtem.

The motions aſcribed to the fixed ſtars are only apparent, and may be accounted for from the real motions of the earth.

The fixed ſtars are placed at immenſe diſtances from each other, and conſequently the neareſt of them is very far from the earth. Our meaſures are too ſmall to expreſs the diſtance of the fixed ſtars; but it has been ſuppoſed to be above 400,000 times the diſtance of the ſun from the earth.

The number of the fixed ſtars is not known: for although thoſe that are viſible have been numbered and arranged in catalogues, it is probable, from what we know of the vaſt extent of the univerſe, and of the ſmall part of it which falls under our view, that the number of ſtars inviſible to us is much greater than that of the viſible; and therefore the number of the whole is entirely unknown.

Some of the fixed ſtars appear large and bright in compariſon of others, which ſeem to be ſmall and ſcarcely diſcernible: for this reaſon we ſpeak of them as greater and leſs; ſuch as ſtars of the firſt, ſecond, third, and fourth magnitudes, &c. But theſe different appearances may be owing to their different diſtances; and the ſtars which appear leaſt may be larger bodies than thoſe which we judge to be the greateſt.

There are a few ſtars which neither continue at the ſame diſtance from each other, nor from the fixed ſtars; but appear in different places of the heavens at different times, and are therefore called *wandering ſtars*: but theſe are not lucid bodies; for although they ſhine like other ſtars, it is only by reflecting the ſun's light which falls on them. Theſe ſtars have many peculiar properties. They are few in number, and very near the ſun and earth in compariſon of the fixed ſtars: they have each their own proper motion round the ſun, beſides other peculiar motions. Some of them revolve round each other. Thoſe which are viſible to us belong to the ſyſtem of the ſun.

By the *univerſe*, we underſtand the whole material creation, which conſiſts of two kinds of great bodies, lucid and opaque.

By

By a *ſyſtem*, we underſtand a lucid body with ſome number of opaque bodies, ſituated within the ſphere of its influence.

There are perhaps as many ſyſtems of this kind in the univerſe as there are fixed ſtars.

The *ſolar ſyſtem* is that part of the univerſe which conſiſts of the ſun, planets, and comets.

CHAP. I.

The Solar Syſtem.

THE SOLAR SYSTEM conſiſts of ſeventeen great bodies; *viz.* the ſun, the ſix primary planets, and ten ſecondary planets or ſatellites; together with the bodies called *comets*, which appear but ſeldom, and their number is as yet unknown.

The ſun and planets are bodies of the ſame form, each of them being nearly a globe.

The ſun is the only lucid body in the ſyſtem, affording light and heat to all the reſt; and is much larger than any of them, his diameter being about 800,000 miles.

The ſun is placed in the centre of his ſyſtem, diffuſing his influences to all the planets; and although he remains in the ſame place, he is not perfectly at reſt, but moves continually round his own axis from weſt to eaſt, making one revolution in about 26 days 6 hours, according to ſome obſervers; and according to others, in 26 days 8 hours nearly.

The planets are all opaque bodies, receiving light from the ſun, and reflecting it in ſuch a manner that they appear to a diſtant obſerver like ſtars: and when the earth and any planet is in ſuch a poſition, with reſpect to the ſun and to each other, that an eye on the earth ſees that ſide of the planet which

which is towards the ſun, the planet has the appearance of a ſtar, more or leſs bright as the whole enlightened ſide or only a part of it is towards the earth; and when the dark ſide is towards the earth, the planet is inviſible to a terreſtrial ſpectator.

The ſix primary planets are, Mercury ☿, Venus ♀, the Earth ⊕, Mars ♂, Jupiter ♃, and Saturn ♄. All theſe revolve continually round the ſun from weſt to eaſt, in different periods of time, according to their diſtances from the ſun and degrees of velocity.

The motion of a primary planet round the ſun is called its *annual motion;* but beſides this, the moſt (if not all) of them revolve continually round their own axis from weſt to eaſt, which is called their *diurnal motion.*

The paths or orbits of the planets are elliptical figures, but not very eccentric; that is, they differ very little from circles.

There are ten ſecondary planets or ſatellites; *viz.* the moon, which is the earth's ſatellite; the four ſatellites of Jupiter; and the five of Saturn. All the ſatellites revolve continually round their primaries from weſt to eaſt; and alſo are carried along with them in their annual motions round the ſun.

The orbits of the planets differ in magnitude; ſome of them being very large, as thoſe of Jupiter and Saturn; and others comparatively ſmall, as the orbits of Mercury and Venus: but the orbits of the ſatellites are the leaſt of all. All the orbits of the planets lie in different planes; and therefore, being produced to the heavens, will cut each other.

The earth's orbit is called the *ecliptic.* The planes of the orbits of the other planets interſect the plane of the ecliptic, making ſmall angles with it; and therefore half of the orbit of every planet lies to the north, and the other half of it to the ſouth of the ecliptic. The points of interſection which

the

the orbit of any planet makes with the ecliptic are called the *nodes*; and the ſtraight line, in which the plane of the orbit of any planet cuts the plane of the ecliptic, is called *the line of the nodes* of that planet.

MERCURY is neareſt to the ſun, and the leaſt of the primary planets: his diameter is about 3,222 miles, and his diſtance from the ſun 37 millions of miles: He makes a revolution round the ſun in 87 days 23 hours 15 minutes, with a velocity of 110 thouſand miles *per* hour: hence his period or year is ſomething leſs than three of our months.

This planet is twice in conjunction with the ſun during every apparent revolution; once between the earth and ſun, called his *inferior*, and again on the oppoſite ſide of the ſun, called his *ſuperior conjunction*; and therefore being always near the ſun, is ſeldom ſeen by a ſpectator on the earth. His greateſt apparent diſtance from the ſun, called his *greateſt elongation*, is only 28 degrees, or 56 times the ſun's diameter; and when the ſun riſes or ſets, mercury is alſo near the horizon, and ſo cannot be ſeen by a ſpectator in our latitude except when he is on the north ſide of the ecliptic and near his greateſt elongation.

When Mercury is viewed through a good teleſcope in every part of his orbit where he is viſible to us, he has all the different phaſes of the moon, except that his diſc is never fully enlightened; becauſe his light ſide is never towards the earth but when he is about his ſuperior conjunction or on the oppoſite ſide of the ſun, where he is hid in the ſun's light; which is a clear proof that he is not a lucid body, emitting his own light; for if he was, his diſc would be always fully lightened and round like the ſun.

Mercury receives near ſeven times as much light and heat from the ſun as our earth. The plane of his orbit is inclined to the plane of the ecliptic in an angle of 7 degrees, and his aſcending node is in 1 s. 15° 46′ 45″, and the other node in 7 s. 15° 46′ 45″. The ſun is in theſe points of the ecliptic

ecliptic on the 6th of May and 7th of November: and when Mercury is in either of his nodes at the time of his inferior conjunction, when he paſſes by between the ſun and earth, he will appear upon the ſun's diſc like a round dark ſpot; but in all other parts of his orbit his conjunctions are inviſible, becauſe he is either above or below the ſun. The tranſits of Mercury over the ſun's diſc, which are viſible in any particular place on earth, happen but ſeldom: one of them will be viſible in Britain in 1799, May 7th, at 2 hours 34 minutes afternoon.

VENUS is the ſecond planet from the ſun, larger than Mercury, but leſs than the earth: her diameter is about 7687 miles, and her diſtance from the ſun 68 millions of miles. She performs her annual revolution round the ſun in 224 days 16 hours 49 minutes, or about 7½ months of our time, which is the length of her year, and goes on with a velocity of 79 thouſand miles in an hour. Venus turns round her own axis continually in 23 hours 22 minutes, which is the length of her day, ſhorter than our natural day by 38 minutes. Her year conſiſts of almoſt 231 of her own days; and ſhe receives twice as much light and heat from the ſun as our earth.

The orbit of Venus lies without the orbit of Mercury, and within the earth's orbit; and therefore, in every apparent revolution, Venus is twice in conjunction with the ſun, in the ſame manner as the planet Mercury. To a ſpectator on the earth, the greateſt apparent diſtance or elongation of Venus from the ſun is only 48 degrees.

Mercury and Venus are called *inferior planets*, becauſe they are nearer to the ſun than any of the reſt; and in their annual motions they appear to a ſpectator on the earth to traverſe forward and backward ſmall ſpaces on each ſide of the ſun, and are frequently in conjunction with him, but never in oppoſition, nor even at 90 degrees diſtance; which is an ocular demonſtration of the truth of the Copernican ſyſtem.

When

When Venus appears on the weſt of the ſun, ſhe riſes before him in the morning, and is then called the *morning ſtar;* and when ſhe appears to the eaſt of the ſun, ſhe ſets after him in the evening, and is the *evening ſtar.* She is in each of theſe poſitions about 290 days together: but is not viſible to us all that time; for when near the ſun on either ſide ſhe is hid in his light.

It may ſeem abſurd to affirm that Venus remains on the weſt or eaſt ſide of the ſun longer than the whole time of her period round him; but while Venus moves through any part of her orbit, the earth moves the ſame way; and therefore her apparent motion, when direct, is only the difference between her own proper motion and that of the earth; and beſides, ſhe appears ſometimes to be ſtationary, and at other times retrograde.

Venus being viewed through a teleſcope, in every part of her orbit has the ſame appearances as the moon, except that her whole diſc is not illuminated unleſs when near her ſuperior conjunction, becauſe ſhe is never in oppoſition to the ſun. Her orbit makes an angle of 3° 23′ 20″ with the ecliptic, and croſſes it in 2s. 14° 51′, which is the longitude of her north or aſcending node, and the ſouth node is in 8s. 14° 51′. When the ſun is in theſe points of the ecliptic, and Venus in her inferior conjunction, ſhe paſſes over the ſun's diſc, appearing like a round black ſpot: but ſuch a poſition of the ſun and planet happen very ſeldom. The laſt tranſit was on the 3d of June 1769, and the next will be in the month of December 1874.

The EARTH is the third planet from the ſun, larger than either of the inferior planets: its diameter is 7,964 miles, and its diſtance from the ſun about 95 millions of miles. The earth revolves continually round the ſun, with a velocity of 68 thouſand miles in an hour.

If we reckon the time of the earth's annual motion round the ſun from the moment of its departure from any point of the

the ecliptic, as the equinox or ſolſtice, until its return to the ſame again, it is 365 days 5 hours 49 minutes nearly, called *the tropical year*; but if we reckon the time as it would appear to a ſpectator in the ſun, from the inſtant when the earth is in conjunction with a fixed ſtar until its return to the ſame, it is 365 days 6 hours 9 minutes 14$\frac{1}{2}$ ſeconds, called the *ſidereal year*.

The velocity of the earth in its annual motion round the ſun is greater than the velocity of any other motion which we are acquainted with; for it is 140 times of the velocity of a ball diſcharged from a gun; and yet the velocity of the earth is little more than half of the velocity of the planet Mercury in his annual motion.

Beſides its annual motion, the earth turns round its own axis from weſt to eaſt once every natural day of 24 hours; whereby the ſun and all the ſtars ſeem to move round the earth, the contrary way from eaſt to weſt, in the ſame time, which produces the continual ſucceſſion of day and night, and is called the *earth's diurnal motion*.

In this motion, thoſe places of the earth at and near the equator move with greater celerity than thoſe which are nearer to the poles; and every point on the ſurface of the earth deſcribes a circle parallel to the equator except the poles, which have no diurnal motion.

Places on the equator move round in the diurnal motion 1042 Engliſh miles every hour. London, in latitude 51° 32′, moves 642 miles an hour; Edinburgh, in latitude 56°, travels 582 miles *per* hour; and Peterſburgh, in latitude 60°, goes round 521 miles an hour: beſides the annual motion of 68,000 miles *per* hour, which is common to all places of the earth.

The axis of a circle is a ſtraight line paſſing through its centre perpendicular to its plane.

The axis of the earth is an imaginary ſtraight line round which it revolves; the extremities of it are the earth's poles; and

and the earth's axis being produced to the viſible heaven, marks out the celeſtial poles.

The earth's axis is inclined to the plane of its orbit in an angle of 66° 32′, and conſequently makes an angle with the axis of its orbit of 23° 28′; which is the ſame with the angle contained between the equator and ecliptic, called the *obliquity of the ecliptic*.

In the earth's motion round the ſun, its axis, although changing place every inſtant, is always parallel to itſelf: for if ſtraight lines be drawn through the ſeveral points of the annual orbit, repreſenting the poſitions of the earth's axis in them, all theſe ſtraight lines will be parallel to each other. It is owing to the inclination of the earth's axis to the plane of its orbit, and its being always parallel to itſelf during the annual motion, that we have the different ſeaſons of ſpring, ſummer, autumn, and winter, ſucceeding each other: for if the earth's axis was perpendicular to the plane of its orbit, the ſun would be conſtantly in the equinoctial circle, which would coincide with the ecliptic, and the days and nights always equal over all the earth, and conſequently there could be no variety of ſeaſons. But by reaſon of the poſition and parallelism of the earth's axis, the ſun appears at the equinoctial circle only twice in the year, and then both poles have his light. From the moment he is in the equinoctial, about the 20th of March, he declines continually towards the north until the 20th of June; when being at his greateſt diſtance from the equinoctial, he begins to return towards it, and on the 22d of September is again on the ſame circle, giving light to both poles. From the 20th of March to the 22d of September all places ſituated north of the equator have their days longer than their nights; and the north pole and places adjacent to it have the ſun's light continually day and night, while the ſouth pole and places near it are in darkneſs. From the 22d of September the ſun appears to decline from the equinoctial ſouthward until about the 22d of

December; when, being at the ſame diſtance from it as he was on the 20th of June, he begins to return towards the north, and on the 20th of March is again at the equinoctial.

While the ſun appears ſouth of the equinoctial, the ſouth pole, and all places in that hemiſphere, have the ſun's light in the ſame manner as the northern had it in the former ſix months.

MARS, the leaſt of all the primary planets except Mercury, is the fourth from the ſun: his diameter is 4,189 miles, and his diſtance from the ſun about 144 millions of miles; he moves round the ſun once in 686 days 23 hours 30 minutes, which is the length of his year; travelling at the rate of 55,000 miles every hour, and turns round his own axis in 24 hours 40 minutes of our time.

The year on this planet is almoſt two of our years, and his natural day 40 minutes longer than ours. His year conſiſts of $668\frac{6}{14}\frac{1}{8}$ of his own days. By reaſon of his greater diſtance, the ſun appears leſs by one half to a ſpectator on Mars than to us on the earth, and conſequently his light and heat is but one half of ours. The axis of Mars is nearly perpendicular to the plane of the ecliptic; his orbit being inclined to it in an angle of no more than two degrees. His aſcending node is in 1 s. 18°, and the ſouth node in 7s. 18°.

The colour of Mars is more red than that of the other planets; and by his appulſes to ſome of the fixed ſtars, he ſeems to be encompaſſed with a very groſs atmoſphere. He appears ſometimes gibbous like the moon in her ſecond and third quarters, but never horned; which ſhows that his orbit includes the earth's within it, and alſo that Mars is not a lucid body emitting his own light, but ſhines by reflecting the light which he receives from the ſun.

JUPITER is the fifth planet from the ſun; much larger than any of the reſt, his diameter being about 89,000 miles; and conſequently this planet is 1,403 times the magnitude of the

the earth. His diſtance from the ſun is 490 millions of miles, and moves round the ſun with a velocity of 29,610 miles per hour; making one revolution in 4,332 days 8 hours $51\frac{1}{2}$ minutes of our time, or 11 years $314\frac{1}{2}$ days nearly, which is the length of his year. He turns round his own axis in 9 hours 56 minutes, which is the length of his natural day. By this diurnal motion, the parts about his equator are carried round at the rate of 28,200 miles every hour, which is almoſt three times the velocity of the earth's diurnal motion.

Jupiter's axis is nearly perpendicular to the plane of his orbit, and therefore he has no ſenſible change of ſeaſons.

The annual orbit of Jupiter is inclined to the plane of the ecliptic in an angle of 1° 20′, and cuts it in 3s. 9°, which is the longitude of his north node, and that of the ſouth node is 9s. 9°.

On account of the great diſtance of Jupiter, the ſun appears to a ſpectator on him to have only one twenty-eighth part of his apparent magnitude as ſeen by us; and conſequently that planet has but the twenty-eighth part of the light and heat which we enjoy.

Saturn, the ſixth planet from the ſun, is greater than any of the primary planets except Jupiter: his diameter is about 79,000 miles, and conſequently his magnitude is near 977 times that of the earth. He is 900 millions of miles diſtant from the ſun, and moves once round him in 10,761 days 14 hours $36\frac{3}{4}$ minutes, or 29 years 169 days 11 hours of our time, which is the length of his year. He moves round the ſun with a velocity of 21,894 miles in an hour. The time of his diurnal rotation round his axis has not been diſcovered as yet.

Saturn is ſurrounded by a large ring, generally ſuppoſed to be ſolid. It is about 21,000 miles in breadth, and at the ſame diſtance from the body of the planet. It is inclined to the plane of the ecliptic in an angle of about 30°, and therefore

fore its apparent form is continually changing; ſometimes appearing as a line acroſs the diſc of the planet, at other times as an oval or a circle. This ornament or conveniency peculiar to Saturn may be ſeen by an ordinary teleſcope; but what it is, or of what uſe, is yet unknown.

The *ſatellites*, or *ſecondary planets*, are ſmall opaque ſpherical bodies, which revolve round their primaries continually, and accompany them in their revolutions round the ſun.

Only three of the primary planets, *viz.* the Earth, Jupiter, and Saturn, have ſatellites. The Earth has one moon, Jupiter four, and Saturn five.

The moon's diameter is only 2,180 miles, and her magnitude about one forty-ninth part of the earth: but much leſs when compared to the ſun; and yet by reaſon of her nearneſs to the earth, ſhe appears to us almoſt as large as the ſun. Her mean diſtance from the earth is about 240,000 miles; and ſhe makes one revolution round the earth in 27 days 7 hours 43 minutes, with a velocity of 2,300 miles *per* hour. This ſpace of time is called the *moon's period.*

In every revolution the moon paſſes once between the ſun and earth; and becauſe ſhe is then in the ſame part of the heavens with the ſun, it is called her *conjunction.* At that time her light ſide is toward the ſun, and her dark ſide toward the earth, and therefore ſhe is inviſible to us. This is vulgarly called the *time of change* or *new moon.* In like manner, in every revolution the moon is once in oppoſition to the ſun; and then her enlightened ſide being toward the earth, we ſee her whole diſc luminous, and ſhe is called *full moon.* When the moon is equally diſtant from her conjunction and oppoſition, we ſee only half of her diſc enlightened, and then ſhe is called *quarter moon.*

The time of a mean lunation or moon, reckoned from one conjunction with the ſun to the next, is 29 days 12 hours 44 minutes 3 ſeconds, called a *ſynodical month;* and in the ſame time

time the moon turns once round her own axis: hence a natural lunar day is about 29½ of our days.

There are many ſpots on the moon's diſc, which move ſlowly, and come always into the ſame poſition at every return of the ſame phaſis; from which it is inferred that the moon turns once round her own axis in every lunation. The moon's axis is ſo nearly perpendicular to the plane of the ecliptic, that ſhe has no change of ſeaſons.

The moon's orbit is a variable ellipſis, ſometimes nearly a circle, and at other times more eccentric: the earth is in one of its foci; it is inclined to the ecliptic in an angle of about 5⅛ degrees; the points where it cuts the ecliptic are called the *moon's nodes;* and the ſtraight line which joins them is called the *line of the nodes.* The moon paſſes once through each node in every lunation; and when ſhe is in either node at the time of her conjunction with the ſun, ſhe intercepts his rays, and prevents them from falling on the earth; becauſe the ſun, earth, and moon, are then in the ſame ſtraight line, and then we ſay the ſun is *eclipſed.*

And when the moon is in her node at the time of oppoſition, the earth being between the ſun and moon, intercepts the ſun's light, and prevents it from falling on the moon's diſc, and thus cauſes an eclipſe of the moon. Hence it appears that eclipſes of the ſun happen only at the time of change or new moon; and eclipſes of the moon can never happen but at the time of full moon.

The reaſon why the time of a mean lunation exceeds the moon's period may be underſtood thus: Suppoſe the moon is in conjunction with the ſun in any point of the ecliptic, the moon moves through her whole orbit in 27 days 7 hours 43 minutes, and in the ſame ſpace of time the earth moves forward in the ecliptic about 27°; and therefore, beſides going once round the earth in her own orbit, the moon muſt go on above two days before ſhe can overtake the earth and be again in conjunction with the ſun.

The

The earth is a moon to the moon, and appears about thirteen times larger to the lunarians than the moon doth to us. They will ſee the ſame changes of the earth as we ſee of the moon. When the moon changes to us, the earth will appear full to them; and when the moon is in her firſt quarter to us, the earth is in her third quarter to them. When the moon is eclipſed to us, the lunarians will ſee the ſun eclipſed by the earth; and when we ſee the ſun eclipſed by the intervention of the moon, the lunarians will ſee the earth eclipſed.

As the earth turns round its axis, the ſeveral continents, iſlands, and ſeas, on its ſurface, will appear to the lunarians like ſo many ſpots of different colours and brightneſs moving over its ſurface; but much fainter at ſome times than at others, as our clouds cover or leave them.

It has been ſaid by ſome that the moon has no atmoſphere: others, with much more reaſon, affirm that it hath; but ſo ſmall in compariſon of the moon's diameter, that it does not exceed one ſecond when viewed by a ſpectator on the earth.

Jupiter has four ſatellites or moons. The firſt or neareſt to him is 229 thouſand miles diſtant from his centre, and moves once round him in 1 day 18 hours 36 minutes of our time; the ſecond is 364 thouſand miles diſtant, and performs one revolution round him in 3 days 13 hours 15 minutes; the third is 580 thouſand miles diſtant, and goes once round him in 7 days 3 hours 59 minutes; and the fourth or outermoſt is one million of miles diſtant from Jupiter, and moves once round him in 16 days 18 hours 30 minutes.

Jupiter is a moon to his moons, and will appear to the inhabitants of that neareſt to him 1,000 times as large as our moon doth to us, and have all the ſame phaſes of our moon in the ſpace of 42½ hours.

Jupiter's three neareſt moons fall into his ſhadow, and are eclipſed in every revolution; but the orbit of the fourth is

ſo

ſo much inclined to the orbit of Jupiter, that it paſſeth through its oppoſition without falling into his ſhadow for two whole years in every ſix. The diſcovery of Jupiter's moons and of their eclipſes have been of great uſe; for by them aſtronomers have diſcovered that the ſun's light takes about 8 minutes of time in coming from the ſun to our earth. By the eclipſes of Jupiter's ſatellites they have alſo determined the longitudes of places on the earth with a greater degree of certainty than by any other method yet known.

Saturn hath five ſatellites or moons. The firſt, or neareſt to him, is 140 thouſand miles diſtant from his centre, and travels once round him in 1 day 21 hours 19 minutes; the ſecond is diſtant 187 thouſand miles, and moves round him once in 2 days 17 hours 40 minutes; the third is diſtant 263 thouſand miles, and goes once round him in 4 days 12 hours 25 minutes; the fourth is diſtant 600 thouſand miles, and makes one revolution round him in 15 days 22 hours 41 minutes; and the fifth, or fartheſt from Saturn, is diſtant from his centre one million of miles, and runs once round him in 79 days 7 hours 48 minutes. Theſe five move continually round Saturn on the outſide of his ring, and their orbits are nearly in the ſame plane with it, and alſo accompany him in his motion round the ſun.

Comets are bodies belonging to the ſolar ſyſtem; but their numbers, magnitudes, orbits, and motions, are very imperfectly known as yet. They are ſaid to be ſolid opaque bodies like the planets, revolving round the ſun in very eccentric orbits, extending far beyond the orbits of the planets. The ſun being in one of the foci of a comet's orbit when it is in perihelion, it muſt be very near the ſun, and then heated to a degree almoſt above our conception; and when it is in aphelion, it muſt ſuffer an equal degree of cold. Some aſtronomers ſay that twenty-one comets belong to the ſolar ſyſtem; of theſe they have calculated only the periods of three: how far they are right, will be known by their regular returns.

returns. The different appearances of comets is as remarkable as any circumſtance concerning them; for ſome of them have appeared bright and round like the planet Jupiter; others have tails projected towards that part of the heavens which is oppoſite to the ſun; and ſome have beards: perhaps the ſame comet may have all theſe forms, ariſing from its different poſitions with reſpect to the ſun and earth.

The number of bodies in the ſolar ſyſtem here deſcribed is that which was generally received by aſtronomers before the year 1780: Since that year another planet has been diſcovered by Mr Herſchel, and called the *Georgium Sidus*.

He ſtates its diameter to be 35 thouſand miles, its diſtance from the ſun 1,800 millions of miles, and its period round the ſun about 83 years. He has alſo diſcovered two ſatellites or moons belonging to this new planet.

The Georgium Sidus viewed through a teleſcope appears like a ſtar of the fourth magnitude, which is not eaſily ſeen by the naked eye; and therefore, whatever advantage aſtronomers may derive from the diſcovery, men in general can derive very little.

CHAP. II.

The Doctrine of the Sphere.

SINCE every ſpectator is in the centre of his own view, and ſince the lucid bodies of the univerſe are placed at immenſe diſtances from each other, wherever a ſpectator is ſituated in the mundane ſpace, he will ſee the viſible heavens have the appearance of a vaſt concave ſurface, of which the centre is his eye. In this apparent ſurface he will ſee innumerable bright ſtars; ſome larger, others leſs, performing their motions: and ſince the diſtance between the earth and

ſun

ſun is but a point in compariſon of the diſtances of the fixed ſtars from the ſun and from one another, a ſpectator will ſee the ſame face of the heavens, the fixed ſtars of the ſame magnitude, and the conſtellations of the ſame form, whether he views them from the earth or from the ſun; and therefore the appearance of the fixed ſtars will be the ſame whether we make the earth or the ſun the centre of the viſible heavens.

In order to form juſt ideas of the ſeveral parts of the earth's ſurface, whether land or water, of their magnitudes, ſituations, and diſtances from each other, and from the place of our reſidence, we ſuppoſe many circles to be deſcribed on the earth; and their planes being produced to the heavens, divide the concave ſurface into ſimilar parts, whereby we can think and ſpeak more intelligibly of their vaſt extent, arrange the ſeveral parts, and deſcribe the phenomena more conveniently than could be done without this contrivance. Theſe are called *circles of the ſphere*, and are either great or ſmall.

The circumference of every circle is divided into 360 equal parts called *degrees*, each degree into 60 minutes, and every minute into 60 ſeconds; and the diviſion may be continued to thirds, fourths, &c.

A great circle hath the ſame centre with the ſphere, and divides it into two equal parts; and a ſmall circle divides the ſphere into two unequal parts.

Small circles are parallel to ſome great circle, and their centres are in a diameter of the ſphere at ſome diſtance from its centre.

The poles of a great circle are two points in the ſurface of the ſphere, diametrically oppoſite, and equally diſtant from every point of the great circle. The poles of a ſmall circle are the ſame with thoſe of the great circle to which it is parallel. Hence parallel circles have the ſame poles.

The axis of a circle is a ſtraight line paſſing through its

centre and poles, and conſequently is perpendicular to its plane.

Great circles which paſs through the poles of another great circle, cut it at right angles, and are called its *ſecondaries*.

Some circles of the ſphere retain always the ſame poſition, and are therefore called *fixed* or *immoveable circles*; others depend on the poſition of the ſpectator, and move along with him, and conſequently are called *moveable circles*.

The equator and ecliptic, with their ſecondaries and parallels, are fixed circles, and are delineated on the artificial globe. The horizon, with its ſecondaries and parallels, are moveable circles, and therefore cannot be delineated on artificial globes.

The axis of the equator is alſo the axis of the earth, and its extremities are the earth's poles: The ſame ſtraight line produced to the heavens marks out the celeſtial poles.

Since the centres of all great circles are in the centre of the ſphere, and every great circle divides the ſphere into two equal parts; when great circles meet on the ſurface of the ſphere, they muſt biſect each other, and the points of their interſection are diametrically oppoſite.

I. *Of the Equator, its Secondaries, and Parallels.*

The EQUATOR, called alſo the *Equinoctial*, and by mariners the *Line*, is a great circle ſurrounding the globe in the middle between the two poles. This circle is commonly called the *equator* when it is conſidered as deſcribed on the earth, and *equinoctial* when extended to the heavens; but theſe terms are often uſed promiſcuouſly.

The earth's axis being the ſame with the axis of the equator, the diurnal motion of the earth is performed in the plane of the equator; and becauſe the apparent motion of the ſtars from eaſt to weſt ariſes from the rotation of the earth round its

its axis from weſt to eaſt, the daily motions of the ſtars are in circles parallel to the equinoctial; that is, any ſtar equally diſtant from both the poles will ſeem to deſcribe the equinoctial by its daily motion; and all the other ſtars will ſeem to deſcribe circles parallel to the equinoctial.

Theſe circles may be called the *diurnal paths of the ſtars*, which decreaſe in magnitude continually according to their diſtance from the equinoctial circle; thoſe near the poles deſcribe very ſmall circles; and if a ſtar be at either pole, it has no diurnal motion, but ſeems to be perfectly at reſt.

The equator divides the earth and alſo the heavens into two equal parts, called the *northern* and *ſouthern hemiſpheres*.

The axis of the equator, called alſo the *axis of the world*, is in the ſame ſtraight line with the earth's axis; and its extremities are the north and ſouth poles, whether of the earth or the heavens. This axis is an imaginary ſtraight line in the heavens, and in artificial globes is repreſented by a wire paſſing through the centre.

Great circles paſſing through the poles and cutting the equator at right angles are ſecondaries of the equator; and with reſpect to places on the earth, they are called *meridians*, and in the heavens are called *circles of aſcenſion*, and ſometimes *hour-circles*.

Becauſe time is reckoned by the diurnal motion of the earth, and this motion is performed in the plane of the equator, therefore the equator is our meaſure of time: for ſuppoſe a fixed celeſtial meridian, while the earth turns round its axis, every point of its ſurface muſt come regularly to this meridian; the whole terreſtrial equator paſſes by the fixed meridian in the ſpace of one natural day of 24 hours; and the 24th part of it, or 15 degrees, will paſs by in one hour, and one degree paſſes in the 15th part of an hour or four minutes. Upon this hypotheſis all machines for meaſuring time, ſuch as ſun-dials, clocks, and watches, are conſtructed; and on the ſame principle, only twelve meridians are drawn on the artificial

artificial terreſtrial globe, cutting the equator in every 15th degree, thereby marking the difference of one hour between the places through which theſe general meridians paſs. The intermediate meridians, although not drawn, are repreſented by other means. When we ſay the ſun or a ſtar comes to the meridian, the terreſtrial meridian is ſuppoſed to be fixed.

The meridian of any point or place is properly a ſemicircle, paſſing through the two poles and that place; the other half of the ſame circle is called the *oppoſite meridian*. Theſe circles, extending from pole to pole, are the meridians of all places through which they paſs; therefore places which lie north and ſouth of each other have the ſame meridian, and conſequently have noon-day at the ſame moment of time.

Every meridian divides both the earth and the heavens into the eaſtern and weſtern hemiſpheres. The poles of every terreſtrial meridian are the eaſt and weſt points of the rational horizon.

One of the general meridians is called the *firſt*, from which the diſtance of the others is reckoned; but the geographers of different nations are not agreed about the ſituation of it: for the Engliſh account the meridian of London or Greenwich the firſt meridian; the French, the meridian of Ferro iſland, one of the Canaries; and the Dutch, that of Teneriff, another of the Canaries. In ſea-charts, the meridian of the Lizard in England, of Cape Finiſterre in Spain, or of Cape Clear in Ireland, is reckoned the firſt, according to the fancy of different authors.

Latitude is the diſtance of a place north or ſouth from the equator, reckoned on the meridian. All places in the northern hemiſphere of the earth are in north latitude, and thoſe in the ſouthern hemiſphere are in ſouth latitude.

Since the latitude of any place is its diſtance from the equator, places ſituated on or under that circle have no latitude; and becauſe the latitudes of places increaſe as they are nearer to the poles, theſe points have the greateſt latitude,

which

which is 90°. Hence the latitude of any place is an arch of the meridian between the equator and that place.

In any place on the earth, the elevation of the pole, or its height above the horizon, is equal to the latitude of the place; which may be illuſtrated thus: In a place ſituated on the equator, the poles are in its horizon; but in a place at any diſtance from the equator, the neareſt pole muſt be as many degrees above the horizon as the place is diſtant from the equator; becauſe there are 90° between the equator and the pole, and the ſame number between the zenith and horizon. If the equinoctial paſs through the zenith, the poles will be in the horizon; but if the zenith be 10° north of the equinoctial, the north pole will be 10° above the horizon, and the ſouth pole as much below it; and the ſame is true of any other diſtance until one of the poles be in the zenith, and then the equator coincides with the horizon.

Longitude is the diſtance of a place from the firſt meridian, eaſt or weſt, reckoned upon the equator. All places in the eaſtern hemiſphere are in eaſt longitude, and thoſe in the weſtern hemiſphere are in weſt longitude. In this method of reckoning the longitude of a place cannot exceed 180°, whether it be eaſt or weſt, becauſe theſe reckonings meet in the oppoſite meridian. But ſome count the longitude from the firſt meridian continually eaſtward round the whole globe, until the reckoning end where it began: in this way they ſpeak of places in 200 and 300 degrees of longitude; and to accommodate their method to the former, when the longitude exceeds 180°, ſubtract it from 360°, and the remainder is weſt longitude.

The longitude of any place is an arch of the equator, between the firſt meridian and the meridian of that place; and may be expreſſed in time by accounting 15 degrees of the equator one hour, every degree 4 minutes, and every minute 4 ſeconds.

When

When circles parallel to the equator are ſuppoſed to be drawn on the earth, they are called *parallels of latitude:* one of them is ſuppoſed to paſs through every point between the equator and the poles. Only a few of them are drawn on the artificial globe; but on maps of the world there is commonly one at every 10th degree of latitude. Their centres are in the earth's axis, and their ſemidiameters are the coſines of the latitude. Their circumferences decreaſe continually as their diſtances from the equator increaſe: and becauſe the circumference of every circle contains the ſame number of degrees, the degrees on the parallels of latitude decreaſe until they vaniſh at the poles.

The length of a degree of longitude on the equator is 60 geographical miles; but a degree on the parallel of 60 degrees of latitude is only one half of that, or 30 miles: and ſuppoſing that the earth is a perfect globe, and a parallel of latitude drawn through every degree of the meridian, the number of miles and decimals of a mile in one degree, on every parallel of latitude, is exhibited in the following table:

A TABLE

A TABLE showing the Number of Miles in a Degree of Longitude, when reckoned on any Parallel of Latitude, from the Equator to the Poles.

Degr. Lat.	Miles.	Degr. Lat.	Miles.	Degr. Lat.	Miles.
0	60.00	31	51.43	62	28.17
1	59.99	32	50.88	63	27.24
2	59.96	33	50.32	64	26.30
3	59.92	34	49.74	65	25.36
4	59.86	35	49.15	66	24.41
5	59.77	36	48.54	67	23.45
6	59.67	37	47.92	68	22.48
7	59.56	38	47.28	69	21.50
8	59.42	39	46.62	70	20.52
9	59.26	40	45.95	71	19.54
10	59.08	41	45.28	72	18.55
11	58.89	42	44.59	73	17.54
12	58.68	43	43.88	74	16.53
13	58.46	44	43.16	75	15.52
14	58.22	45	42.43	76	14.51
15	57.95	46	41.68	77	13.50
16	57.67	47	40.92	78	12.47
17	57.37	48	40.15	79	11.45
18	57.06	49	39.36	80	10.42
19	56.73	50	38.57	81	9.38
20	56.38	51	37.76	82	8.35
21	56.01	52	36.94	83	7.32
22	55.63	53	36.11	84	6.28
23	55.23	54	35.26	85	5.23
24	54.81	55	34,41	86	4.18
25	54.38	56	33.55	87	3.14
26	53.93	57	32.68	88	2.09
27	53.46	58	31.79	89	1.05
28	52.97	59	30.90	90	0.00
29	52.47	60	30.00		
30	51.96	61	29.09		

The

The diſtance of any point or ſtar in the heavens from the equinoctial is called its *declination*, which in all reſpects is the ſame with *latitude* on the earth; for it is an arch of the celeſtial meridian between the equinoctial and the ſtar, and is either north or ſouth according as the ſtar is on the north or ſouth ſide of the equinoctial.

Parallels of latitude on the earth being extended to the heavens are called *parallels of declination*, and are the apparent diurnal paths of the ſtars.

Four of the parallels of latitude and declination are remarkable, and diſtinguiſhed by particular names, *viz.* the *two tropics* and the *two polar circles*.

The tropics are on different ſides of the equator, each of them being $23\frac{1}{2}$ degrees diſtant from it. That which is in the northern hemiſphere is called the *tropic of Cancer*, becauſe it touches the ecliptic in the beginning of the ſign Cancer; and the other in the ſouthern hemiſphere is called the *tropic of Capricorn*, becauſe it touches the ecliptic in the beginning of the ſign Capricorn. Theſe two circles are the limits of the ſun's declination.

The polar circles are deſcribed round the poles at the diſtance of $23\frac{1}{2}$ degrees. That on the north is called the *arctic circle*, from the name of a conſtellation in the heavens through which it paſſes, and hence we call this the *arctic pole*: the other at the ſame diſtance from the ſouth pole is called the *antarctic circle*, as being oppoſite to the former; and for the ſame reaſon this pole is called the *antarctic pole*.

In all places of the earth between the polar circles the ſun riſes and ſets daily, dividing the 24 hours into day and night; but within the polar circles there are times of the year when the ſun neither riſes nor ſets: for within the arctic circle, while the ſun is on the north ſide of the equinoctial, he ſhines on the north pole ſix months; in places near it he ſhines five months without ſetting; and in other places he ſhines four, three, two, and one month, according as they are near to or further

further from the pole; and when the ſun is on the ſouth ſide of the equinoctial, he is as long inviſible, being below the horizons of theſe places. And the ſame is the caſe in places within the antarctic circle, according as the ſun is on the ſouth or north ſides of the equinoctial. Hence at the poles the year conſiſts only of one day and one night; therefore the polar circles are the limits of all that ſpace on the earth's ſurface where the ſun riſes and ſets every day.

The tropics and polar circles divide the ſurface of the earth into five parts called *zones*, viz. one torrid, two temperate, and two frigid zones.

The ſpace between the two tropics, having the equator in the middle of it, is called the *torrid zone*, on account of the exceſſive heat of the ſun; for he is vertical to every part of it twice every year: and although he is ſtill moving ſlowly northward or ſouthward, he continues nearly vertical to the ſame place for ſeveral days together, and is never very far from that poſition in compariſon of ſome other places of the earth. This zone is the largeſt of the five, being 47 degrees broad; and comprehends a part of Aſia, a great part of Africa, and South America, with the adjacent ſeas and iſlands.

The inhabitants of the torrid zone have the ſun ſometimes to the ſouth and at other times to the north of their zenith at noon; and therefore their noon-day ſhadows fall towards the north or towards the ſouth according to the poſition of the ſun, and for this reaſon they are called *amphiſcians*. When the ſun is in the zenith at noon, the inhabitants have no ſhadow, and therefore are called *aſcians* or *ſhadowleſs*.

Beſides what is already mentioned, there are ſeveral other things peculiar to the torrid zone, ſuch as the trade-winds, monſoons, ſea and land breezes.

The trade-winds blow always from ſome point near the eaſt: On the north ſide of the equator they blow from near north-eaſt towards ſouth-weſt: on the ſouth ſide of the equa-

tor they blow from ſouth-eaſt, and about the equator from eaſt; but here the winds are ſometimes variable, and there are frequently calms which continue days or weeks without any wind at all. The trade-winds extend beyond the tropics to the latitude of 30 degrees north and ſouth.

The monſoons are periodical winds which blow ſix months from near north-eaſt towards the ſouth-weſt, and other ſix months in the oppoſite direction. The change happens about the time of the equinoxes, and is accompanied with great winds, thunder, and rain. The monſoons are felt only in the Indian ſeas on the coaſts of Aſia, and do not extend above 200 leagues from the land.

The ſea and land breezes blow from noon till midnight from the ſea, and from midnight till noon from the land, and extend only a few leagues from the ſhore. It is not eaſy to aſſign the true cauſe of theſe periodical winds. In the torrid zone the year is not divided into ſummer and winter as it is in the temperate zones, but into the dry and rainy ſeaſons: their worſt weather happens when the ſun is in or near their zenith.

The temperate zones are next to the torrid, one on the north and the other on the ſouth ſide. They are called *temperate*, becauſe in them the air is neither ſo hot as it is in the torrid zone, nor ſo cold as in the frigid zones, but a mean between both.

The ſpace between the tropic of Cancer and the arctic circle is called the *north temperate zone*: it is 43 degrees broad, and comprehends almoſt all Europe, the greateſt part of Aſia, a ſmall part of Africa, and a great part of North America, with the adjacent ſeas and iſlands. In this zone the ſun being always ſouth of the zenith, the ſhadows of the inhabitants fall northward at noon. The days and nights are unequal, except at the times of the equinoxes. The winds are variable; and blow from every point of the compaſs at different

different times, but more frequently from the weſt than from any other point.

The ſpace between the tropic of Capricorn and the antarctic circle is called the *ſouth temperate zone;* which is alſo 43 degrees broad, and comprehends a ſmall part of Africa and of South America, with a part of New Holland, as alſo the adjacent ſeas and iſlands. Here the days and nights are always unequal except at the equinoxes: the winds are variable; and the ſun being always north of the zenith, the noon-day ſhadows of the inhabitants fall continually ſouthward.

The inhabitants of the temperate zones are called *Heteroſcians*, becauſe their noon-day ſhadows fall always the ſame way.

The ſpace comprehended by the arctic circle having the north pole in the middle of it, is called the *north frigid zone*, on account of the intenſe cold which prevails there. Reckoning from any point in the arctic circle to the oppoſite point of the ſame, this zone is 47 degrees broad, and contains a very ſmall part of Europe and of Aſia, Eaſt and Weſt Greenland, with Nova Zembla, and ſome unknown parts of North America. There is very little habitable land here, and very few inhabitants.

The ſouth frigid zone is the ſpace comprehended by the antarctic circle, which in extent and all other reſpects is the ſame with the north frigid zone, only we know of no land in the ſouth frigid zone. Mariners who have been far ſouth, ſay that the cold is more intenſe in high ſouth latitudes than in the ſame degrees of north latitude.

The inhabitants of the frigid zones are called *Periſcians;* becauſe when the ſun is continually above their horizon, their ſhadows fall towards every point around them in the ſpace of 24 hours.

Beſides the diviſion of the earth's ſurface into zones by the tropics and polar circles, another diviſion of it has been made

made into parts leſs than the former, by circles parallel to the equator, called *climates*.

A *climate* is a tract of the earth's ſurface contained between the equator and a parallel of latitude, or between two parallels of latitude, and of ſuch a breadth that the length of the longeſt day on one ſide of it exceeds that in the other by half an hour. This is true of all the climates between the equator and either polar circle; but within theſe circles in the frigid zones the breadth of a climate is ſuch, that the time of the ſun's continuance above the horizon in one of the bounding parallels, exceeds that time in the other by one month.

At the equator the days and nights are always equal, each being 12 hours; but in places ſituated north or ſouth of the equator, the day and night are never equal except at the time of the equinoxes. When the ſun is on the ſame ſide of the equator with any place, the days there are longer than 12 hours and the nights ſhorter; and when the ſun is on the contrary ſide of the equator, the days are ſhorter and the nights longer than 12 hours: and the farther any place is from the equator, the greater is the difference between the days and nights until we come to the polar circle, where the longeſt day is 24 hours; for then the ſun does not ſet, but only touches the horizon at midnight.

If we move ſo far from the equator directly north or ſouth until the longeſt day be $12\frac{1}{2}$ hours, and draw a parallel of latitude through that place, the ſpace between the equator and that parallel is the firſt climate: and if we go on from the equator towards either pole, until the longeſt day be 13 hours, and there draw another parallel, the ſpace between this and the former parallel is the ſecond climate; and by ſuppoſing parallels to be drawn in the ſame manner through every place, where the longeſt day exceeds that in the former parallel by half an hour, until we come to the polar circle, we ſhall have 24 climates between the equator and the arctic circle,

circle, and as many between the equator and the antarctic circle, or 48 climates reckoned by half hours.

At the polar circles the longeſt day is 24 hours; but within them, towards the poles, the ſun continues above the horizon for ſeveral days or months without ſetting, increaſing towards the poles, where the longeſt day is ſix months.

If we move from either polar circle towards the neareſt pole to the place where the ſun continues one month above the horizon, and there draw a parallel of latitude, the ſpace between the polar circle and this parallel is the firſt month climate; and in the ſame manner, by ſuppoſing parallels drawn through the places where the ſun continues 2 months, 3 months, &c. above the horizon, we ſhall have ſix climates within each polar circle, or 12 climates reckoned by months, which with the 48 reckoned by half hours makes 60 climates in all.

Theſe climates decreaſe continually in breadth the farther they are from the equator. The parallel of latitude in which they begin and end, with their reſpective breadths, is exhibited in the following table.

Climates			

CLIMATES between the Equator and the Polar Circles.

Climates.	Longeſt Day.	Latitude.	Breadth.	Climates.	Longeſt Day.	Latitude.	Breadth.
	H.	D. M.	D. M.		H.	D. M.	D. M.
1	12½	8 25	8 25	13	18½	59 58	1 29
2	13	16 25	8 0	14	19	61 18	1 20
3	13½	23 50	7 25	15	19½	62 25	1 7
4	14	30 25	6 30	16	20	63 23	0 57
5	14½	36 28	6 8	17	20½	64 6	0 44
6	15	41 22	4 54	18	21	64 49	0 43
7	15½	45 29	4 7	19	21½	65 21	0 32
8	16	49 1	3 32	20	22	65 47	0 26
9	16½	52 0	2 57	21	22½	66 6	0 19
10	17	54 27	2 29	22	23	66 20	0 14
11	17½	56 37	2 10	23	23½	66 28	0 8
12	18	58 29	1 52	24	24	66 32	0 3

CLIMATES between the Polar Circles and the Poles.

Length of Days.	Latitude.	Length of Days.	Latitude.
Months.	D. M.	Months.	D. M.
1	67 21	4	78 30
2	69 48	5	84 5
3	73 37	6	90 0

In this table both the hours and latitudes anſwer to the parallel where the climate ends: For example, the firſt climate begins at the equator and ends in latitude 8° 25′, and there the longeſt day is 12½ hours. The ſecond climate begins at 8° 25′ and ends at latitude 16° 25′, where the longeſt day is 13 hours; and ſo on in the reſt.

II. *Of*

II. *Of the Ecliptic, its Secondaries, and Parallels.*

THE ecliptic is the annual path of the earth round the ſun, or the apparent annual path of the ſun in the heavens: for wherever the earth is in its orbit, a ſpectator on it will ſee the ſun in the oppoſite point of the ſame circle.

This circle is named *ecliptic* from the word *eclipſe;* becauſe the eclipſes of the ſun and moon never happen but when the moon is in or near its plane. One half of the ecliptic lies on the north ſide of the equinoctial, and the other half on the ſouth. The interſections of theſe circles are called the *equinoctial points*, where they form an angle of 23 degrees 28 minutes, which is named the *obliquity of the ecliptic*. One of theſe points is called the *vernal equinox* and the other the *autumnal*. When the ſun is in either equinox, both poles of the earth are enlightened, and all places of the earth have equal day and night.

There are two points of the ecliptic equally diſtant from the equinoctial points, and fartheſt from the equinoctial circle, called the *ſolſtitial points:* that on the north of the equinoctial is named the *ſummer ſolſtice* by us who dwell on the north ſide of the equator, and the other on the ſouth the *winter ſolſtice*. In the diurnal rotation of the earth, the ſolſtitial points deſcribe the two tropics, and the equinoctial points deſcribe the equator.

The ecliptic, like all other circles of the ſphere, is divided into 360 degrees, and is farther divided into 12 equal parts called *ſigns*, each ſign containing 30 degrees, which begin at the vernal equinox, and are numbered eaſtward round the whole circle.

The names and characters of the ſigns, with the months when the ſun enter them, are as follow:

1. Aries

1. Aries	♈	March	7. Libra	♎	September
2. Taurus	♉	April	8. Scorpio	♏	October
3. Gemini	♊	May	9. Sagittarius	♐	November
4. Cancer	♋	June	10. Capricornus	♑	December
5. Leo	♌	July	11. Aquarius	♒	January
6. Virgo	♍	Auguſt	12. Piſces	♓	February

The ſun is in the beginning of the ſign ♈ on the 20th of March, which is the time of the vernal equinox; and he enters each of the other ſigns about the 20th day of the month, but not exactly ſo.

The ecliptic divides the viſible heavens into the northern and ſouthern hemiſpheres, but ſome place the zodiac between theſe hemiſpheres.

The ſigns are divided into the northern and ſouthern, and alſo into the aſcending and deſcending. The firſt ſix are called the *northern ſigns*, becauſe they are all on the north ſide of the equinoctial; and the other ſix are called *ſouthern ſigns*, becauſe they are ſouthward of the equinoctial. The aſcending ſigns begin at the moſt ſoutherly point of the ecliptic, and extend to the moſt northerly, *viz.* Capricornus, Aquarius, Piſces, Aries, Taurus, Gemini; the other ſix are called *deſcending ſigns*, viz. Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius.

The meridian which paſſes through the equinoctial points is called the *equinoctial colure*, and that which paſſes through the ſolſtitial points is called the *ſolſtitial colure*. Theſe meridians cut each other at right angles in the poles of the equinoctial, and divide the ecliptic and equinoctial, as alſo the whole viſible heavens, into four equal parts. The equinoctial colure may be called the *firſt celeſtial meridian*, becauſe the longitudes of the ſtars are reckoned from it, and the ſolſtitial colure cuts both the ecliptic and equinoctial at right angles.

The poles of the ecliptic are points in the ſolſtitial colure 23 de-

23 degrees 28 minutes distant from the poles of the equinoctial. While the earth turns round its axis, the poles of the ecliptic describe the polar circles.

Great circles passing through the poles of the ecliptic cut it at right angles, and are called its *secondaries*; but with respect to the heavens, are called *circles of longitude*.

The longitude of a star, or of any point in the heavens, is an arch of the ecliptic, between the vernal equinox and the circle of longitude, passing through the star or point, reckoned in the order of the signs.

The latitude of a star is its distance from the ecliptic, reckoned on a circle of longitude, passing through the star; and is either north or south, according as the star is on the north or south side of the ecliptic.

Small circles parallel to the ecliptic are called *parallels of latitude* in the heavens: One of them is supposed to pass through every point of the solstitial colure, or of any circle of longitude.

The zodiac is a space of 16 degrees broad in the heavens; *viz.* 8 degrees on each side of the ecliptic, contained between two parallels of celestial latitude. The orbits of all the planets are within the zodiac, and the fixed stars in it are divided into 12 constellations, having the same names with the signs, and in former times situated in the same places: but now in a different situation; for by a slow motion of the equinoctial points westward, called the *precession of the equinoxes*, the stars appear farther east than formerly; so that the constellation Pisces is now in the sign Aries, and the constellation Aries is in the sign Taurus, &c.

A constellation is a number of stars situated in the neighbourhood of one another on the surface of the celestial sphere; which astronomers, for the sake of numbering them with greater ease, suppose to be circumscribed by the outlines of some animal or other figure; by this means the mo-

tions of the planets and comets are more readily deſcribed and compared.

The fixed ſtars are divided into ſix claſſes, of as many different magnitudes. Thoſe that appear largeſt, occaſioned probably by their being nearer to us than the reſt, are called *ſtars of the firſt magnitude;* and the next to them in bigneſs are ſaid to be of the ſecond magnitude; and ſo on until we come to ſtars of the ſixth magnitude, which are the ſmalleſt that can be ſeen by the naked eye. Beſides theſe, there are a vaſt number which cannot be ſeen without a teleſcope; and theſe are called *teleſcopic ſtars*. There is no other rule for claſſing the ſtars but the eſtimation of the obſerver; and hence it is that ſome aſtronomers reckon thoſe ſtars of the firſt magnitude which others eſteem to be of the ſecond.

The number of conſtellations is 78, each containing ſeveral ſtars of different magnitudes. The names of the conſtellations, and the number of ſtars in them, is contained in the following tables; where they are diſtinguiſhed into three heads, *viz.* the conſtellations in the zodiac, in the northern and ſouthern hemiſpheres.

TABLE I.

TABLE I. *CONSTELLATIONS in the ZODIAC.*

Names.	Number of Stars	Names.	Number of Stars.
Aries -	46	Libra - -	33
Taurus -	109	Scorpio -	44
Gemini -	94	Sagittarius -	48
Cancer -	75	Capricornus -	58
Leo - -	91	Aquarius -	93
Virgo - -	93	Piſces - -	110

TABLE II. *NORTHERN CONSTELLATIONS.*

Names.	Number of Stars.	Names.	Number of Stars.
Little Bear -	12	Camelopardalus	23
Great Bear -	105	Serpent -	50
Draco -	49	Serpentarius	67
Cepheus -	40	Sobieſki's Shield	8
Grey Hounds	24	Eagle -	29
Bootes -	53	Antinous -	34
Mons Mœnalus	11	Dolphin -	18
Berenice's Hair	24	Colt - -	12
Charles's Heart	3	Arrow -	13
Northern Crown	11	Andromeda -	66
Hercules -	92	Perſeus -	67
Cerberus -	9	Pegaſus -	81
Harp - -	24	Auriga -	46
Swan -	73	Lynx - -	55
Fox - -	29	Little Lion -	20
Gooſe - -	10	Great Triangle	10
Lizard - -	12	Little Triangle	5
Caſſiopeia -	52	Muſca -	6

TABLE III.

TABLE III. *SOUTHERN CONSTELLATIONS.*

Names.	Number of Stars.	Names.	Number of Stars.
Whale - -	80	Peacock - -	14
Eridanus -	72	Southern Crown	12
Phœnix -	13	Crane - - -	14
American Gooſe	9	Southern Fiſh	15
Orion - -	93	Hare -	25
Monoceros -	32	Noah's Dove	10
Little Dog -	14	Charles's Oak	13
Hydra -	53	Ship Argo -	48
Sextans Uraniæ	4	Great Dog -	29
Cup - -	11	Bee - -	4
Crow - - -	8	Swallow -	11
Centaur -	36	Indus -	12
Wolf - -	36	Chameleon -	10
Altar - -	9	Flying Fiſh -	7
Southern Triangle	5	Sword Fiſh -	7

TABLE IV. *The CONSTELLATIONS, with the Number of STARS of the ſeveral MAGNITUDES contained in them.*

		Magnitudes.						
		1ſt	2d	3d	4th	5th	6th	Tot.
Conſtellations in the zodiac	12	6	12	38	100	169	569	894
In the northern hemiſphere	36	5	21	92	200	291	634	1243
In the ſouthern hemiſphere	30	9	32	75	185	188	217	706
		20	65	205	485	648	1420	2843

There are but few ſtars of the firſt and ſecond magnitudes in compariſon of the others; and in places above 50 degrees of north latitude only about 45 of theſe can be ſeen.

Some

Some ſingle fixed ſtars have names, ſuch as Aldebaran, Betelgueſe, Sirius, Caſtor, &c. alſo ſome cluſters of ſtars, as the Pleiades or ſeven ſtars in the conſtellation Taurus, &c.

The conſtellations have been delineated on globes called *artificial celeſtial globes*, and alſo on maps of the heavens called *hemiſpheres*: and in theſe repreſentations the ſtars are diſtinguiſhed by the letters of the Greek alphabet; thus the firſt letter is affixed to the largeſt ſtar in each conſtellation; the ſecond letter to the next largeſt; and ſo on through all the ſtars in that conſtellation, whereby any ſtar is eaſily pointed out.

Aſtronomers obſerve, that ſeveral ſtars mentioned by the ancients have diſappeared, and are not now found in the heavens; and alſo that ſeveral ſtars are viſible in our times which were not ſeen by the aſtronomers of former ages; and, finally, that there are ſtars which appear and diſappear periodically.

The right aſcenſion of the ſun or any ſtar is an arch of the equinoctial intercepted between the vernal equinox and the meridian paſſing through the ſun or ſtar, and may be expreſſed either in degrees or in time, allowing 15 degrees to an hour.

III. *Of the Horizon, its Secondaries, and Parallels.*

If from any given point on the ſurface of the earth a ſtraight line be drawn through its centre, and produced infinitely both ways, it will meet the viſible heavens in two oppoſite points, whereof the one neareſt to the given point is called the *zenith*, and the other the *nadir*; therefore the zenith of any place on the earth is the point in the heavens directly over the head of the ſpectator, and the nadir is the point in the heavens diametrically oppoſite to the zenith.

There are two horizons, the *rational* and *ſenſible*.

The

The *rational* horizon is a great circle in the heavens, whoſe plane paſſes through the centre of the earth, dividing the heavens into the upper and lower hemiſpheres: its poles are the zenith and nadir.

The *ſenſible* horizon is parallel to the rational; its plane touches the earth in the place of the ſpectator, and its circumference is the boundary of his view. The centre of the rational horizon is the ſame with the centre of the earth, and the centre of the ſenſible horizon is the eye of the ſpectator. The diſtance between the two horizons is the ſemidiameter of the earth, which is near 4,000 miles; but this diſtance is only a point when compared to the diſtance of the ſun and fixed ſtars; for when the centre of the ſun or of any ſtar is at the rational horizon, it is ſeen at the ſame moment in the ſenſible horizon; but the moon being very near the earth in reſpect of the ſun and ſtars, comes firſt to the rational horizon at riſing, and after ſome time appears in the ſenſible. In what follows we ſpeak of both theſe horizons as one and the ſame circle.

Circles which paſs through the zenith and nadir of any place cut the horizon at right angles, and are called its *ſecondaries*; but with reſpect to the heavens, they are called *vertical* or *azimuth circles*. One of them is ſuppoſed to paſs through every point of the horizon; or there may be as many azimuth circles as there are points in the horizon.

There are two principal vertical circles, *viz.* the meridian and the prime vertical, which cut each other at right angles in the zenith, and divide the horizon into four equal parts or quadrants. The meridian paſſes through the north and ſouth points of the horizon, and the prime vertical through the eaſt and weſt points of it. Each quadrant of the horizon is farther divided into eight eqaal parts, or the whole into 32 parts, called *points of the mariner's compaſs*, whereby the poſition of places on the earth is known, and by theſe and the magnetic

magnetic needle ſailors are enabled to find their way through the ocean from any place to any other.

In all places of the earth, except the two poles, the horizon cuts the equinoctial into two equal parts; and in places ſituated on the equator, the horizon cuts all the parallels of declination into two equal parts, one half of each parallel being above and the other below it; and hence the ſun and every ſtar is 12 hours above and as long below the horizon; but in places between the equator and polar circles, the horizon cuts the parallels of declination into unequal parts. In places between the equator and the elevated pole, the greateſt parts of theſe parallels are above the horizon; and in places between the equator and the depreſſed pole, the leaſt parts are above, and the greater parts below, the horizon. The parts of the parallels of declination which are above the horizon of any place are called *diurnal arcs*, and the parts below are called *nocturnal arcs*.

By the diurnal motion of the earth, the ſun, or any object in the heavens, appears firſt at the horizon in the eaſt, when it is ſaid to riſe; from thence it aſcends continually till it appears in the meridian, where, being at its greateſt altitude, it is ſaid to culminate; and then it deſcends until it diſappears or ſets in the weſt.

The ſun, or any ſtar in the equinoctial circle, riſes due eaſt, and ſets due weſt, to all places of the earth, except the poles; but in places having north latitude, the ſun, or a ſtar, which has north declination, riſes between eaſt and north, and ſets between weſt and north; and a ſtar which has ſouth declination, riſes between eaſt and ſouth, and ſets between weſt and ſouth. The diſtance of the ſun or any ſtar from the eaſt at riſing, or from the weſt at ſetting, is called its *amplitude*; which is always of the ſame name with its declination. The ſun or a ſtar, when in the equinoctial, has no amplitude.

The amplitude of a fixed ſtar continues the ſame for many years;

years; but the amplitudes of the ſun and planets vary with their declinations.

Stars, whoſe declinations are leſs than the complement of the latitude of the place, riſe and ſet every natural day; but thoſe ſtars, whoſe declinations are of the ſame name with the latitude, and greater than its complement, neither riſe nor ſet, but are continually above the horizon, or within the circle of perpetual apparition; and ſtars, whoſe declinations are of a contrary name to the latitude, and greater than its complement, are always below the horizon, or within the circle of perpetual occultation.

The horizon of any place, and the ecliptic, being great circles of the ſphere, biſect each other. That point of the ecliptic which is at the eaſtern part of the horizon, is called the *aſcending point*; and the oppoſite point at the weſtern part of the horizon is called the *deſcending point*; and the point of the ecliptic in the middle between theſe two is called the 90th *degree*, which is the higheſt point of it at that time.

The angle contained between the ecliptic and horizon varies continually, and the altitude of the 90th degree is always the meaſure of this angle.

The point of the ecliptic which is on the meridian at any time is called the *mid-heaven*, and the point of the equinoctial then on the meridian marks its right aſcenſion.

The altitude of the mid-heaven is found by adding or ſubtracting its declination to or from the complement of the latitude of the place, according as they are of the ſame or a contrary name.

The point of the equinoctial which riſes with the ſun or any ſtar is called its *oblique aſcenſion*, and that point of the ſame circle which ſets with the ſun or any ſtar ſhows its oblique deſcenſion.

In places ſituated on the equator, the oblique aſcenſion or deſcenſion of the ſun or any ſtar is always the ſame with the right aſcenſion; but in all other places they differ, and the diffe-

difference between the right and oblique aſcenſion is called the *aſcenſional difference*; which, with reſpect to the ſun, is the time he riſes before or after ſix o'clock.

The altitude of the ſun, or of any ſtar, is an arch of a vertical circle, paſſing through the centre of the ſun or ſtar, intercepted between it and the horizon. If the ſtar be on the meridian, its altitude is the meridian altitude, and its complement is called the *zenith diſtance*.

The *azimuth* of the ſun, or of any ſtar, is an arch of the horizon reckoned from north or ſouth to the vertical circle which paſſes through the centre of the ſun or ſtar. When a ſtar is on the meridian it has no azimuth.

Small circles parallel to the horizon, between it and the zenith, are called *almicanthers* or parallels of altitude: one of them is ſuppoſed to paſs through every point of the meridian or of the prime vertical. They decreaſe in magnitude as they approach to the zenith.

The terms *right ſphere*, *parallel ſphere*, and *oblique ſphere*, ariſe from the poſition of the ſeveral circles with reſpect to a ſpectator ſituated in different places of the earth.

If a perſon be on the earth's equator, the poles are in his horizon; the equinoctial paſſes through his zenith, and cuts the horizon at right angles; alſo all the parallels of declination are at right angles to the horizon; and therefore this poſition is called a *right ſphere*, wherein the days and nights are always equal to one another, and every ſtar is 12 hours above the horizon, and appears to move in a circle perpendicular to it.

If a perſon be at either of the earth's poles, one of the celeſtial poles will be in his zenith and the other in his nadir; the meridians will be vertical circles; the equinoctial will coincide with his horizon, and all the parallels of declination will be parallel to his horizon; and therefore this poſition is called a *parallel ſphere*, wherein the year conſiſts of one day and one night, each being ſix months long; becauſe half of

the ecliptic is above and the other half below the horizon, and all the ſtars will deſcribe circles parallel to it.

But if a perſon be on any place of the earth between the equator and either pole, the equinoctial and all its parallels will cut his horizon obliquely; and therefore this poſition is called an *oblique ſphere*; where the days and nights are never equal except at the time of the equinoxes, but the ſum of all the days of the year will be about ſix months; therefore every place of the earth has the ſame ſhare of the ſun's light.

In places near the equator, the inhabitants have nearly a right ſphere: among theſe we may include the whole torrid zone. The obliquity of the ſphere increaſes with the latitude of the place, until we come within a few degrees of the pole, and there it is nearly a parallel ſphere.

The inhabitants of the earth, with reſpect to their relative ſituations, are diſtinguiſhed by the names *Periæci*, *Antæci*, and *Antipodes*.

If any place be taken on the earth between the equator and the pole, and a parallel of latitude drawn through it, the periæci of that place is in the oppoſite point of that parallel. A place and its periæci are in the ſame latitude but oppoſite meridians; their difference of longitude is 180 degrees or 12 hours. They have ſummer and winter at the ſame time, but oppoſite hours; for when it is noon-day in the one, it is midnight in the other.

If a place be taken at ſome diſtance from the equator and poles, its antæci is in the ſame meridian, and at the ſame diſtance from the equator, but on the other ſide of it: For example, if a place be in 50° of north latitude, its antæci is in 50° of ſouth latitude, and under the ſame meridian. A place and its antæci have noon-day and every other hour at the ſame time: but they have oppoſite ſeaſons of the year; for when it is ſummer in the one it is winter in the other, and the days in the one are equal to the nights in the other.

If

If a place be taken anywhere on the ſurface of the earth, the place or point diametrically oppoſite is its antipode. A place and its antipode are oppoſite in all reſpects. The days, nights, and ſeaſons, are in oppoſite times; the zenith of a place is the nadir of its antipode; and if two men ſtand in places that are antipodes to each other, the feet of the one will be oppoſite to the feet of the other, and their heads will point towards oppoſite points in the heavens.

The ancient poets mention three different riſings and ſettings of the ſtars, *viz.* the *coſmical*, *achronical*, and *heliacal*; where the words *riſing* and *ſetting* have a meaning different from that in common language.

A ſtar is ſaid to riſe or ſet *coſmically* when it riſes or ſets in the morning at ſun-riſing.

A ſtar riſes *achronically* when it riſes at the time of ſun-ſetting, and ſets achronically when it ſets at ſun-riſing; that is, when it is in oppoſition to the ſun.

A ſtar riſes *heliacally* when, after being hid in the ſun's ſplendor, it is again at ſuch a diſtance from him as to become viſible in the morning before ſun-riſing; and a ſtar ſets heliacally when the ſun is ſo near as to render it inviſible.

The common ſection of the planes of the meridian and horizon is a ſtraight line, which when drawn on the earth is called the *meridian line*.

PROB. I. *To mark out the Meridian Line of any place.*

ON any ſmooth ſurface which is level or parallel to the horizon deſcribe a circle, and place a ſtyle in its centre perpendicular to the plane, of ſuch a length that the extremity of its ſhadow may fall on the circumference of the circle ſome time before noon-day; mark the point where it falls. In the afternoon watch the time when the end of the ſhadow falls again on the circumference of the circle, and mark alſo that point. Biſect the diſtance between theſe marked points, and

and draw a ſtraight line through the centre and the biſecting point, which will be the meridian line of that place.

Having found the direction of the meridian line, ſome diſtant hills or buildings may be fixed on to extend its length.

In order to have a true meridian line, the operation ſhould be renewed on ſeveral different days; and thoſe near the time of the ſolſtice are the moſt proper.

PROB. II. *To find the Latitude of a place.*

OBSERVE the altitude of any fixed ſtar ſituated near the pole when it is on the meridian above the pole, and again when it is on the meridian below the pole; theſe altitudes being corrected by ſubtracting the refraction, taken out of the Table, p. 13. half of their ſum is the latitude of the place.

In the northern parts of the world, ſuch as Britain, &c. the moſt proper time for this obſervation is in the months of December and January: for any circumpolar ſtar which is on the meridian in the evening above the pole will be again on the meridian below the pole at the ſame hour in the morning, and *vice verſa*.

Stars which have the ſame right aſcenſion with the ſun are on the meridian at noon-day; but thoſe ſtars which have right aſcenſions different from the ſun's, come to the meridian after him; and here the hours are reckoned from 1 to 24, becauſe the aſtronomical day begins and ends at noon.

The ſun's right aſcenſion increaſes about one degree or 4 minutes of time every day: but the right aſcenſion of a fixed ſtar is the ſame for many days together; the variation ſeldom exceeds 5 or 6 ſeconds of time in a year.

PROB.

PROB. III. *To find the Time when any known Fixed Star will be on the Meridian any given Day.*

Find the right aſcenſion of the ſun for the noon of the given day, and of the ſtar for the year and month; then ſubtract the ſun's right aſcenſion from that of the ſtar, the remainder is the time nearly: And

As 24 hours is to the daily difference of the ſun's right aſcenſion; ſo is the hours in the remainder to a number which is to be ſubtracted from it; and the remainder will be the true time when the ſtar is on the meridian.

EXAM. What time is the bright ſtar of Pleiades on the meridian of Greenwich 3d December 1795?

	h.	m.	s.
Sun's R. A. December 4th -	16	43	37
Ditto - - 3d -	16	39	16
Daily difference - -	0	4	21

h. m. s. h. m. m. s.
As 24 : 4 21 :: 10 56 : 1 58

	h.	m.	s.
Star's R. A. in time, December 1795 -	3	35	22
Sun's R. A. in do. Decem. 5. at noon -	16	39	16
Approximate time - -	10	56	6
Subtract the equation -	0	1	58
Star on the meridian - -	10	54	8

The bright ſtar of Pleiades is on the meridian of Greenwich at 10 h. 54 m. 8 s. and the ſame ſtar is on the meridian of any other place within 15° of longitude eaſt or weſt of Greenwich very nearly at the ſame time; the hours being reckoned in the meridian of that place. For the ſun's right aſcenſion

aſcenſion varies only about 4 minutes in 24 hours, or 10 ſeconds in 1 hour, or 15 degrees of longitude; therefore places differing leſs than 30° of longitude will have the ſame fixed ſtars on their meridians nearly at the ſame hours. But to find when any known ſtar will be on the meridian of a given place,

Find when the ſtar is on the meridian of Greenwich, and allow 10 ſeconds of time for every 15° of longitude; which is to be ſubtracted from the time at Greenwich for places in weſt longitude, and added for places in eaſt longitude.

EXAM. What time is the ſtar Aldebaran on the meridian of Philadelphia, longitude 75° 18′ W. or 5 h. 1 m. 12 s. December 3d 1795?

	h.	m.	s.
Star's R. A. in Decem. 1795 -	4	24	13
Sun's R. A. 1795 Decem. 3d at noon -	16	39	16
	11	44	57
For 11 h. 45 m. ſubtract - -	0	2	9
Star on the meridian of Greenwich -	11	42	48
For 5 hours weſt longitude ſubtract -	0	0	50
Aldebaran on the meridian of Philadelphia	11	41	58

2. What time is the ſtar Aldebaran on the meridian of Pekin in China, longitude 116° 21′ 30″ E. or 7 h. 45 m. 26 s. Decem. 3. 1795?

	h.	m.	s.
Aldebaran on the meridian of Greenwich	11	42	48
For about 8 hours eaſt longitude add -	+	1	20
Aldebaran on the meridian of Pekin at -	11	44	8

That is, when it is 11 h. 44 m. at Pekin, the ſtar Aldebaran is on the meridian.

1. Hence

1. Hence it appears, that the ſame fixed ſtar is on the meridian of every place in any kingdom of moderate extent nearly at the ſame hour reckoned in that place. For ſince there are only 10 ſeconds of time between the times that a fixed ſtar is on the meridians of two places differing 15 degrees in longitude, there cannot be above 5 or 6 ſeconds between places whoſe difference of longitude is only 7 or 8 degrees; which being very ſmall, may be ſafely neglected.

2. Any fixed ſtar is on the meridian at the ſame hour on the ſame day of the month for many years together; for in 40 years the difference will not exceed one or two minutes of time.

The knowledge of the time when a fixed ſtar is on the meridian any given day, is of uſe both for learning to know the ſtars and for regulating clocks and watches. For if one knows what the meridian is and its ſituation in the heavens, and alſo the time when any ſtar will be on it, he needs only to look at the ſtar at that time, and obſerve its ſituation with reſpect to other ſtars, to know it again; becauſe the fixed ſtars retain always the ſame ſituation and diſtance from each other.

By practiſing according to this rule, all the remarkable ſtars viſible in the obſerver's hemiſphere may be known.

The motions of clocks or watches may be examined, and their errors rectified, by this rule; for if the equation of time be applied to the apparent time when a ſtar is on the meridian, the mean time, which the clock ſhould ſhow, will be known, and conſequently its error diſcovered. For example, if one knows that the bright ſtar in Pleiades is on the meridian December 3d, at 10 h. 54 m. 8 s. apparent time, let him ſubtract the equation of time 9 m. 28 s. from 10 h. 54 m. 8 s. and the remainder, 10 h. 44 m. 40 s. is the true mean time which the clock ſhould ſhow when that ſtar is on

the

the meridian; and ſince the time when any known ſtar is on the meridian any given night may be found in the ſame manner, this is the eaſieſt method of regulating clocks or watches, and may be practiſed either by mariners at ſea or travellers on land.

The following table contains the right aſcenſions and declinations of a few principal fixed ſtars, adapted to the beginning of the year 1796, with their annual variations; and alſo their meridian altitudes in latitude 56 degrees north.

TABLE I.

TABLE I. *Of Right Aſcenſions, Declinations, and Meridian Altitudes of Stars, in Latitude 56° north.*

Names of the Stars.	Magni.	Right Aſcenſ.	Annual Variat.	Declinat.	Annual Variat.	Merid. Alt.
		h. m. s.	″	° ′ ″	″	° ′
γ Pegaſi Algenib	2	0 2 44	3.06	14 2 55 N	+20.	48 3
Alruccabah Pole	2	0 50 24	10.05	88 13 13	+19.69	57 47 N
β Androm. Mirach	2	0 58 22	3.30	34 32 7	+19.45	68 32
α Arietis -	2	1 55 43	3.33	22 29 39	+17.60	56 29
γ Ceti, Menkar	2	2 51 38	3.13	3 16 51	+14.80	37 17
β Meduſa, Algol	2	2 54 57	3.85	40 9 31	+14.63	74 9
Aldebaran -	1	4 24 13	3.42	16 5 12	+ 8.26	50. 5
Capella -	1	5 1 38	4.41	45 46 24	+ 5.21	79.46
Rigel -	1	5 4 42	2.80	8 26 53 S	— 4.88	25.33
Betelgueſe -	1	5 44 7	3.24	7 21 20 N	+ 1.51	41.21
Sirius - -	1	6 36 10	2.65	16 26 47 S	+ 4.25	17.33
Caſtor -	2	7 21 33	3.85	32 19 10 N	— 6.85	66.19
Procyon. Lit. Dog	1	7 28 36	3.14	5 44 42 N	— 7.45	39.45
Cor. Leo. Regulus	1	9 57 29	3.14	12 57 31 N	—17.19	46.58
α Urſa Major Upper Pointer	2	10 51 2	3.88	62 51 0 N	—19.09	83. 9 N
Alioth, Urſa Maj.	2	12 45 0	2.67	57 4 15 N	—17.09	88.56 N
Spica Virginis	1	13 14 27	3.13	10 5 28 S	+19.04	23.54
Tail, Urſa Maj.	2	13 15 39	2.43	55 59 44 N	—19.0	90. 0
Arcturus -	1	14 6 23	2.72	20 15 33 N	—17.15	54.16
Antares -	1	16 16 55	3.64	25 57 50 S	+ 8.84	8. 2
α Lyra Vega	1	18 30 1	2.01	38 35 58 N	+ 2.54	72.36
Altair -	1	19 40 48	2.90	8 20 12 N	+ 8.44	42.20
Fomalhaut	1	22 46 20	3.33	30 41 54 S	—18.97	3.18
α Pegaſi Markab	2	22 54 37	2.98	14 6 37 N	+19.20	48. 7

When the R. A. of a ſtar is wanted for any other year, multiply the annual variation by the difference between 1796 and the given year; and if the given year is before 1796, ſubtract the product from the R. A. in the table; but if after it, add.

For the declination of a ſtar for any year after 1796, multiply the annual variation by the number of years, and add or ſubtract the product to or from the declination in the table, according to the ſigns + or —; and for years before apply the product contrary to the ſign of the variation in the table.

TABLE II. *Containing the Times when ſome of the Stars in* Table I. *will be on the Meridian the firſt Day of every Month in the Year; which will ſerve for any place in Britain.*

JANUARY 1.			MARCH 1.		
Names of the Stars.	h.	m.	Names of the Stars.	h.	m.
α Arietis -	7	7	Sirius -	7	43
α Ceti - -	8	3	Caſtor -	8	28
Algol -	8	7	Procyon -	8	35
Aldebaran -	9	35	Regulus -	11	4
Capella -	10	12	α Urſa Major	11	57
Rigel -	10	15	Alioth -	13	50
Betelgueſe -	10	6	Spica -	14	20
Sirius -	11	47	η Urſa Major	14	21
Caſtor -	12	33	Arcturus -	15	12
Procyon -	12	39	Antares -	17	22
Regulus -	15	7	APRIL 1.		
FEBRUARY 1.			Regulus -	9	10
Aldebaran -	7	23	α Urſa Major	10	4
Capella -	8	1	Alioth -	11	57
Rigel -	8	4	Spica -	12	27
Betelgueſe -	8	43	η Urſa Major	12	28
Sirius -	9	35	Arcturus -	13	18
Caſtor -	10	20	Antares -	15	29
Procyon -	10	27	MAY 1.		
Regulus -	12	56	Spica -	10	35
α Urſa Major	13	49	η Urſa Major	10	37
Alioth -	15	43	Arcturus -	11	27
Spica -	16	12	Antares -	13	37

Note, Becauſe of the difference between the ſolar and civil years, there is a ſmall variation in the ſun's R. A. on the ſame days of the month every year, and conſequently in the time when the ſtars come to the meridian; but this difference is ſo ſmall that it may be neglected in moſt caſes, and then the times marked in the table will ſerve for many years to come: but the intention of the table is not ſo much for the preciſe time, as to aſſiſt one in knowing the ſtars.

TABLE II. *Continued.*

JUNE 1.			NOVEMBER 1.		
Names of the Stars.	h.	m.	Names of the Stars.	h.	m.
Arcturus -	9	25	Altair -	5	10
Antares -	11	35	Fomalhaut	8	15
Vega - -	13	47	Markab -	8	24
JULY 1.			Algenib -	9	32
Vega - -	11	43	North Pole	10	19
Altair -	12	54	α Arietis -	11	24
AUGUST 1.			α Ceti - -	12	20
Vega -	9	39	Algol - -	12	23
Altair -	10	50	Aldebaran -	13	52
Fomalhaut	13	55	Capella -	14	30
Markab -	14	3	Rigel -	14	33
SEPTEMBER 1.			Betelgueſe -	15	12
Vega -	7	44	Sirius -	16	4
Altair -	8	55	Caſtor -	16	49
Fomalhaut -	12	0	Procyon -	16	56
Markab -	12	8			
Algenib -	13	16	DECEMBER 1.		
North Pole -	14	3			
β Andromeda	14	11	Fomalhaut	6	11
α Arietis -	15	9	Markab -	6	20
OCTOBER 1.			Algenib -	7	27
Altair -	7	7	North Pole Star	8	25
Fomalhaut	10	12	α Arietis -	9	20
Markab -	10	20	α Ceti - -	10	16
Algenib -	11	3	Algol - -	10	19
North Pole	12	16	Aldebaran -	11	48
α Arietis -	13	21	Capella - -	12	25
α Ceti - -	14	16	Rigel - -	12	28
Algol -	14	20	Betelgueſe -	13	8
Aldebaran -	15	50	Sirius - -	14	0
Capella -	16	26	Caſtor - -	14	55
Rigel -	16	29	Procyon -	14	52
Betelgueſe.	17	8	Regulus -	17	20

Stars

Stars of the firſt and ſecond magnitudes are viſible from about an hour after the ſun ſets in the evening until an hour before the ſun riſes in the morning, when the ſky is clear.

In the long nights of winter many ſtars may be ſeen on the meridian every night when the ſky is free of clouds; but in the months of May, June, and July, the nights are ſo ſhort that few ſtars are viſible in places above 50 degrees of latitude.

Thoſe ſtars which are on the meridian at midnight in the month of December are inviſible in the month of June; for then they are on the meridian about mid-day: and the ſame thing is true of the ſtars in any other oppoſite months of the year; ſuch as March and September, &c. This is owing to the apparent annual motion of the ſun in the ecliptic.

When it is required to find out any ſtar contained in theſe tables in the heavens,

Look for the ſtar in Table I. and for its right aſcenſion and declination. If the ſtar be viſible the firſt day of the month, the time it is on the meridian will be found in Table II.: and for any other day, the time when the ſtar is on the meridian may be found by the rule; and having the time when the ſtar is on the meridian, it is only neceſſary to look to the heavens then, to find out the ſtar and diſtinguiſh it from the reſt. Any ſtar will be eaſier found in the heavens if its meridian altitude is known.

PROB. IV. *The Latitude of the place and the Declination of a Star being given, to find the Meridian Altitude of the Star.*

IF the latitude of the place and the declination of the ſtar are of the ſame name, that is, both north or both ſouth, add the declination of the ſtar to the complement of the latitude; the ſum, if leſs than 90°, is the meridian altitude of the ſtar; but if the ſum be greater than 90°, its ſupplement is the meridian altitude.

If

If the latitude of the place and the declination of the ſtar are of contrary names, ſubtract the declination of the ſtar from the complement of the latitude, the remainder is the meridian altitude of the ſtar.

Note, If the declination of the ſtar is equal to or greater than the complement of the latitude, and of a contrary name, the ſtar is never above the horizon of that place.

EXAM. 1. What is the meridian altitude of the ſtar Menkar in latitude 51° 28′ 39″ north, in the year 1796?

	°	′	″
Comp. of the latitude - -	38	31	21
Menkar's declination north - -	3	16	51
Anſwer - -	41	48	12

2. Required the meridian altitude of the ſtar Bellatrix, Orion's Shoulder, at Edinburgh, latitude 55° 58′ north, in the year 1796?

	°	′	″
Comp. of the latitude - -	34	2	0
Declination of the ſtar north -	6	9	5
Anſwer - -	40	11	5

3. What is the meridian altitude of the ſtar Fomalhaut at Rome, latitude 41° 53′ 54″ north, in the year 1796?

	°	′	″
Comp. of the latitude - -	48	6	6
Declination of the ſtar ſouth - -	30	41	54
Anſwer - -	17	24	12

The altitude of a fixed ſtar, when it is on the meridian of any place, is nearly the ſame for many years.

4. Required the meridian altitude of the ſtar Hydra's Heart

Heart at the Cape of Good Hope, latitude 33° 55′ 15″ ſouth, in the year 1796?

	°	′	″
Comp. of the latitude - -	56	4	45
Declination of the ſtar ſouth - -	7	46	52
Anſwer - -	63	51	37

PROB. V. *To find that Day of the Year when any Fixed Star will be on the Meridian at a given Hour; the Star's Right Aſcenſion being known.*

SUBTRACT the given hour from the ſtar's right aſcenſion; the remainder is the ſun's right aſcenſion on the day required: which being found in a table of the ſun's right aſcenſion for every day in the year, the day will be known.

EXAM. 1. It is required to find that day in the year 1796 when the ſtar Aldebaran will be on the meridian at 7 h. 23 m. 16 s. P. M.?

	h.	m.	s.
The R. A. of Aldebaran 1796 is -	4	24	13
Subtract the given hour - -	7	23	16
The ſun's R. A. is - -	21	0	57

Which anſwers to the 1ſt day of February.

2. What day in the year 1796 will the bright ſtar of Aries be on the meridian at 9 hours P. M.? Anſ. December 6th.

	h.	m.	s.
Star's R. A. 1796 is - -	1	55	43
Subtract the given hour - -	9	0	•
Sun's R. A. - - -	16	55	43

Which anſwers to December 6th.

3. What

3. What day in the year 1729 was the ſtar Sirius on the meridian at 8 h. 30. m. P. M.? Anſ. February 17th.

			h.	m.	s.
Annual Var.	2.65	Star's R. A. in 1796	6	36	10
Years -	67	Var. in 67 years ſubt.	—	2	57
	1855	Star's R. A. in 1729	6	33	13
	1590	Subt. the given hour	8	30	0
60)	177.55	Sun's R. A. -	22	3	13
	2′ 57″	Which anſwers to the 17th Feb.			

N. B. From this example it appears, that a fixed ſtar is on the meridian within 3 minutes of the ſame time during 67 years.

CHAP. III.

Of the Diviſion of Time.

THE KALENNDAR.

THE integral meaſure of time is a year, which is either *tropical* or *ſidereal.*

The *tropical* year is the time wherein the earth makes one revolution round the ſun, or in which the ſun appears to move round the whole ecliptic, conſiſting of 365 days 5 hours 48 minutes and 55 ſeconds. This is commonly called the *ſolar year.*

The *ſidereal* year is the time between two conjunctions or oppoſitions of the ſun and a fixed ſtar, which conſiſts of 365 days 6 hours 9 minutes $14\frac{1}{2}$ ſeconds; and exceeds the ſolar year by 20 minutes $17\frac{1}{2}$ ſeconds.

A *month* is the 12th part of a year, or the quantity of time wherein the ſun apparently paſſes through one ſign or the 12th part of the ecliptic.

Theſe years and months are eſtimated by the apparent motion of the ſun; but ſome nations, both in ancient and modern times, reckon time by the motions of the moon.

A *lunar month* is the time from one conjunction of the moon with the ſun until the next; which at a mean rate is 29 days 12 hours 44 minutes 3 ſeconds; and 12 of theſe months make a lunar year, which is 354 days 8 hours 48 minutes and 36 ſeconds.

A *natural day* is the time wherein the earth turns once round its axis, reckoned from noon or midnight to the next; divided into 24 equal parts called *hours*.

An *artificial day* is the time the ſun is above the horizon; reckoned from ſun-riſing until he ſets, which is always variable.

Civil time is the method of reckoning years, months, and days, in common uſe; and differs from the aſtronomical in ſeveral reſpects.

A civil year is either *common* or *biſſextile*. A common year conſiſts of 365 natural days, diſtributed into 12 months; but the ſolar year exceeds this time by almoſt 6 hours, which in 4 years amounts nearly to one day; therefore every fourth year conſiſts of 366 days. The intercalary day is placed next after the 24th of February; and becauſe in the Roman reckoning this day was the ſixth before the kalends of March, and in ſuch years was twice reckoned; therefore every 4th year is called *biſſextile*, and vulgarly *leap year*.

This method of reckoning time was introduced by *Julius Cæſar* about 40 years before the Chriſtian era, and from him called the *Julian account*: But although Julian years come near to the ſolar, they do not coincide; for 4 Julian years exceed 4 ſolar years by about 44 minutes, which in 130 years amounts to one day, and in 1300 years to 10 days.

For

For this reaſon Pope Gregory ordered 10 days to be omitted in the year 1582, accounting the 5th day of October the 15th; and that the laſt year of every century, not diviſible by 4, ſuch as 17 hundred, 18 hundred, 19 hundred, ſhould be a common year of 365 days, which in the Julian account were biſſextile years of 366 days; but that the laſt years of ſuch centuries as were diviſible by 4, as 16 hundred, 20 hundred, 24 hundred, ſhould conſiſt of 366 days, as in the Julian account: and thus the civil and ſolar years agree ſo nearly, as not to differ above one day in 5,082 years. This reckoning is called the *Gregorean* or *new ſtyle*.

PROB. I. *Any Year being propoſed, to find whether it is a Leap Year or a common Year.*

DIVIDE the given year by 4: if 0 remains, it is leap year; if 1, 2, or 3 remains, it is the 1ſt, 2d, or 3d, after leap year. Obſerving that the years 1700, 1800, 1900, are common years.

EXAM. 1. Is 1804 a common or a leap year?

4)1804

451, and 0 remains; therefore it is leap year.

2. Is 1809 a common or a leap year?

4)1809

452, and 1 remains. It is the 1ſt after leap year.

Note, in theſe diviſions the quotient is the number of leap years ſince the beginning of the Chriſtian era.

The length of the civil year being determined, with the months, and the number of days in every month, a regiſter of theſe is called the *kalendar*.

In the kalendar it has been uſual to mark the ſeven days of every week with the firſt ſeven letters of the alphabet; always calling the 1ſt of January A, the 2d B, the 3d C, the 4th D, the 5th E, the 6th F, and the 7th G; the 8th A, the 9th B; and ſo on throughout the year: and whatever letter falls to the firſt Sunday of January will anſwer to every Sunday in a common year; and is therefore called the *dominical letter*.

A common year contains 52 weeks and 1 day; therefore the firſt and laſt days of a common year fall on the ſame day of the week. Suppoſe any year began on Monday, the next begins on Tueſday, and the next again on Wedneſday, and ſo on through every day of the week; but this continues only 3 years, and breaks off in the fourth. If every year conſiſted of 365 days, the dominical letters would run backward through all the ſeven continually; but this order is interrupted by the leap years; for in theſe, February having one day more than in common years, the firſt dominical letter in March and for the reſt of the year will be the letter preceding that which ſerved for January and February; therefore leap year hath two dominical letters, but they go on ſtill in a retrograde order.

PROB. II. *To find the Dominical Letter for any Year until the Year* 1800.

To the given year add its 4th part (not regarding fractions), and divide the ſum by 7: if 0 remains, G is the dominical letter; but if there is a remainder, ſubtract it from 7, and the remainder ſhows the dominical letter, reckoning A = 1, B = 2, C = 3, &c.

EXAM.

EXAM. 1. Required the dominical letter for the year 1797?

4)1797
449
7)2246
320 remains 6

And 7—6=1; then A is the dominical letter, and the year begins on Sunday.

2. Required the dominical letter for 1799?

4)1799
449
7)2248
321 remains 1.

And 7—1=6; then F is the dominical letter, and the year begins on Tueſday.

After the year 1799 the dominical letter is found as before; only after dividing by 7, ſubtract the remainder from 8, and the laſt remainder ſhows the dominical letter.

EXAM. 1. Required the dominical letter for the year 1807?

4)1807
451
7)2258
322 remains 4.

And 8—4=4; therefore D is the dominical letter, and the year begins on Thurſday.

2. Re-

3. Required the dominical letter for 1812?

4)1812
453
7)2265
323 remains 4.

And 8—4=4; then D is the dominical letter. But 1812 being leap year, hath two dominical letters, *viz.* E and D. In the months January and February the dominical letter is E, and D in the reſt of the months. The year begins on Wedneſday.

If every year conſiſted of 365 days, there would be only ſeven changes of the dominical letters, going on continually in a retrograde order; but every 4th year interrupts this order, and therefore there are 4 times 7 or 28 changes of the dominical letters: hence all the varieties of the dominical letters happen in 28 years. This period is called the *cycle of the ſun*. Now if the dominical letters be calculated for 28 years, they are known for ever; becauſe they return in the ſame order during the next 28 years, and go on continually except when interrupted by the laſt year of a century, not diviſible by 4. At the birth of Chriſt 9 years of this cycle had paſt.

PROB. III. *Any Year being given, to find what Year of the Solar Cycle it is.*

ADD 9 to the given year, and divide the ſum by 28, the quotient is the number of cycles paſt, and the remainder is the year of the preſent cycle. If nothing remain, the given year is the 28th of the cycle.

EXAM.

EXAM. Required the cycle of the ſun in the year 1800? *Anſ.* The 17th year of the 65th cycle.

Given year - 1800
Add - - 9

28)1809(64
168

129
112

Remainder 17

2. Required the cycle of the ſun in the year 1811? *Anſ.* The cycle is 28, or the year 1811 completes the 65th cycle ſince the beginning of the Chriſtian era.

1811
Add - 9

28)1820(65

Remainder 0

About 432 years before the Chriſtian era, Meton an Athenian found, that 19 ſolar years contained 235 mean lunations; ſo that the mean new and full moons fall on the ſame days of the month in any year as they did 19 years before, or as they will do 19 years after.

This period is called the *cycle of the moon*; and in old kalendars the current year of it was wrote in letters of gold at the days of the month on which the mean new moons fell; and hence it has been called the *golden number* or *prime*. The Chriſtian era began on the 2d year of this cycle.

PROB.

PROB. IV. *To find the Cycle of the Moon or Golden Number for any given Year.*

ADD 1 to the given year, and divide the ſum by 19; the quotient is the number of cycles elapſed ſince the beginning of the Chriſtian era, and the remainder is the current year of the cycle, or the golden number for that year. If nothing remains, the golden number is 19.

EXAM. 1. Required the golden number in the year 1797? *Anſ.* 12.

	1797
Add	1
	19)1798(94
Remains	12

2. What is the golden number in the year 1803? *Anſ.* 18.

	1803
Add	1
	19)1804(94
Remains	18

The golden number is the ſame in both the Julian and Gregorean ſtyles, and increaſes by unity in every ſucceeding year from 1 to 19, and then begins again at 1: thus, if the golden number in any year be 6, 12 years after it will be 18. Therefore, having the golden number for any year, to find it for any future year, take the difference of the years, and add it to the given golden number: if the ſum is leſs than 20, it is the anſwer; but if it exceeds 19, divide it by 19, and the remainder is the golden number required.

EXAM.

Exam. In the year 1786 the golden number is 1: If it be required for 1807, the difference of the years is 21; then add 21 to 1, and divide the ſum 22 by 19, and the remainder 3 is the golden number for the year 1807.

In like manner, the golden number for 1700 is 10; to find it for 1800, to the given golden number 10 add the difference of the years 100, and divide the ſum 110 by 19, the remainder 15 is the golden number for the year 1800.

By the golden numbers diſpoſed as in the following table, the day of mean new moon in any month may be known until the year 1900.

The golden numbers are placed under the months, and oppoſite to the day of mean new moon in the left hand column.

Table I.

TABLE I.

Days	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	9	17	9	17	17	6	14	3	11	11	19	8
2					6			11			8	
3	17	6	17	6		14	3		19	19		16
4	6				14			19	8	8	16	
5		14		14		3	11				5	5
6	14	3	14	3	3	11	19	8	16	16		13
7	3		3	11	11	19		16	5	5	13	
8		11			19	8	8	16				2
9	11	19	11	9					13	13	2	10
10			19	8	8	16	16	5	13	2	10	
11	19	8						13	2	2		18
1	8	6	8	16	16	5				10	18	7
13					5	13	13	2	10			
14	16	5	16	5			2	10	18	18	7	
15	5		5	13	13	2				7		15
16		13			2	10	10	18	7		15	
17	13	2	13	2			18	7		1	4	4
18	2		2	10	10	18			15			12
19		10			18	7	7	15	4	4	12	
20	10	18	1	18			15			12	1	1
21	8		18	7	7	15		4	12			9
22		7			15	4	4	12	1	1	9	
23	7	15	7	15			12			9	17	17
24			15	4	4	12		1	9			6
25	15	4			12		1	9	17	17	6	
26	4		4	12		1	9	17	6	6		14
27		12		1	1	9					14	
28	12	1	12		9		9	17	6	14	3	3
29	1		1	9		17	17	6	14	3		11
20					17	6	6	14	3		11	
31	9		9				14	3		11		19

Yrs.	G.N.
1786	1
1787	2
1788	3
1789	4
1790	5
1791	6
1792	7
1793	8
1794	9
1795	10
1796	11
1797	12
1798	13
1799	14
1800	15
1801	16
1802	17
1803	18
1804	19
1805	1
1806	2
1807	3
1808	4
1809	5
1810	6
1811	7
1812	8
1813	9
1814	10
1815	11
1816	12
1817	13

To find the day of mean new moon, in any month of a given year, by the table,

Find the golden number for the year under the given month, and oppoſite to it, in the left hand column, is the day of new moon.

N. B. The ſmall table on the right hand ſhows the golden number.

EXAM. 1. Required the day of mean new moon in Auguſt 1798?

The golden number for the year is 13.

In the table, below Auguſt, 13 is found oppoſite to 11 in the column of days; therefore the mean new moon is on the 11th day of Auguſt 1798.

2. Required the day of mean new moon in December 1798?

The golden number 13 is found below December, oppoſite to 7 in the column of days; therefore the mean new moon is on the 7th day of December 1798.

The day of mean new moon being known, add $7\frac{1}{4}$ days to it for the mean time of 1ſt quarter; 15 days for the mean full moon; and $22\frac{1}{4}$ days for the 3d quarter.

The difference between a mean ſolar and lunar year is 10 days, 21 hours, 11 minutes, 23 ſeconds; which (to avoid fractions) is commonly reckoned 11 days; and this conſtitutes the annual epact.

When the ſolar and lunar years begin together, the epact for that year is 0 or 29; the 2d year the epact is 11; the 3d it is 22; and the 4th 33; but when the epact exceeds 30, an intercalary month of 30 days is added, making the lunar year conſiſt of 13 months; therefore the epact at the beginning of the 4th year is only 3; the 5th year it is 14; the 6th year it is 25; and the 7th it is 36, or only 6, on account of the intercalary month; and ſo on, the epact of every year

exceeding that of the former year by 11. All the variety of annual epacts happen in one lunar cycle of 19 years; and during the next, they recur in the same order as before.

PROB. V. *To find the Epact for any given year less than* 1900.

Find the golden number; multiply it by 11, and divide the product by 30; then subtract 11 from the remainder, and the epact will be known.

If the remainder is less than 11, add 30 to it, and subtract 11 from the sum; the last remainder is the epact.

EXAM. 1. Required the epact for the year 1799? *Ans.* 23.

The golden number is	14
Multiply by	11
	30) 154 (5
	150
Remains	4
Add	30
	34
Subtract	11
The epact	23

2. Required the epact in the year 1809? *Ans.* 14.

The golden number is	5
×	11
	30) 55 (1
	30
Remains	25
Subtract	11
The epact	14

Note

Note 1. The epact of any year is the age of the moon on the first day of January, or the number of days since the last mean new moon.

2. Some call the moon's age on the first of March the *epact of the year*: the reason is, the moon's age is the same on the first day of each of these months; because there are 59 days, or two mean lunations, in January and February.

The following Table contains the solar cycles, dominical letters, golden numbers, and epacts, for 31 years; and may be extended at pleasure by the foregoing rules.

TABLE II.

Years.	Solar Cycles.	Dom. letter.	Golden N.	Epacts.	Years.	Solar Cycles.	Dom. letter.	Golden N.	Epacts.
1797	14	A	12	1	1813	2	C	9	28
1798	15	G	13	12	1814	3	B	10	9
1799	16	F	14	23	1815	4	A	11	20
1800	17	E	15	4	B 1816	5	GF	12	1
1801	18	D	16	15	1817	6	E	13	12
1802	19	C	17	26	1818	7	D	14	23
1803	20	B	18	7	1819	8	C	15	4
B 1804	21	A G	19	18	B 1820	9	BA	16	15
1805	22	F	1	29	1821	10	G	17	26
1806	23	E	2	11	1822	11	F	18	7
1807	24	D	3	22	1823	12	E	19	18
B 1808	25	C B	4	3	B 1824	13	DC	1	29
1809	26	A	5	14	1825	14	B	2	11
1810	27	G	6	25	1826	15	A	3	22
1811	28	F	7	6	1827	16	G	4	3
B 1812	1	ED	8	17	B 1828	17	FE	5	14

PROB. VI. *The Dominical Letter being known, to find what day of the week any day of a given month falls on.*

WHEN the days of the year are marked by the ſeven firſt letters of the alphabet repeated continually, the letter A is always at the firſt day of January and October; B at the firſt of May; C at the firſt of Auguſt; D at the firſt of February, March, and November; E at the firſt of June; F at the firſt of September and December; and G at the firſt of April and July; or, according to the diſtich,

At, Dover, Dwells, George, Brown, Eſquire,
Good, Charles, Finch, And, David, Friar;

where the firſt letter of every word marks the firſt day of each month in the year; and the ſame letters mark the 8th, 15th, 22d, and 29th, days of the month.

If the dominical letter is A, the 1ſt day of January and of October are Sundays; the 1ſt of February, March, and November, being marked with D, are Wedneſdays; the 1ſt of April and of July, marked with G, are Saturdays; the 1ſt of May, marked B, is Monday; the 1ſt of June, marked E, is Thurſday; the 1ſt of Auguſt, marked C, is Tueſday; the 1ſt of September and of December, marked F, is Friday; and the 8th, 15th, 22d, and 29th, of the month are on the ſame days of the week.

EXAM. What day of the week is the 7th of July 1797? *Anſ.* Friday.

The dominical letter in 1797 is A: the 1ſt of July is G, or Saturday, and conſequently the 7th of July is Friday.

The following Table ſhows what days of the month are Sundays throughout any year; and conſequently the day of the week that a given day of any month falls on.

TABLE III

TABLE III. *Showing what Days of the Week the Days of the Months fall on by the Dominical Letters.*

Week Days.	A.	B.	C.	D.	E.	F.	G.
	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
January 31.	15	16	17	18	19	20	21
October 31.	22	23	24	25	26	27	28
	29	30	31				
				1	2	3	4
	5	6	7	8	9	10	11
February 28-29.	12	13	14	15	16	17	18
March 31.	19	20	21	22	23	24	25
November 30.	26	27	28	29	30	31	
							1
	2	3	4	5	6	7	8
	9	10	11	12	13	14	15
April 30.	16	17	18	19	20	21	22
July 31.	23	24	25	26	27	28	29
	30	31					
			1	2	3	4	5
	6	7	8	9	10	11	12
	13	14	15	16	17	18	19
Auguſt 31.	20	21	22	23	24	25	26
	27	28	29	30	31		
						1	2
	3	4	5	6	7	8	9
	10	11	12	13	14	15	16
September 30.	17	18	19	20	21	22	23
December 31.	24	25	26	27	28	29	30
	31						
		1	2	3	4	5	6
	7	8	9	10	11	12	13
	14	15	16	17	18	19	20
May 31.	21	22	23	24	25	26	27
	28	29	30	31			
					1	2	3
	4	5	6	7	8	9	10
	11	12	13	14	15	16	17
June 30.	18	19	20	21	22	23	24
	25	26	27	28	29	30	

Uſe

Uſe of the Table.

When it is required to find the day of the week that a day of any month in a given year is, the dominical letter being known,

Look for the dominical letter on the head of the table, and for the month in the left hand column, oppoſite to which, and under the dominical letter, are all the Sundays in that month; and the Sunday next to the given day being found, reckon forward or backwark to the day required.

Exam. 1. What day of the week is the 13th Sept. 1800? *Anſ.* Saturday.

The dominical letter is E; under E, and oppoſite to September, the 14th day is Sunday; therefore the 13th is Saturday.

A week day being propoſed, ſuch as the 2d or 3d Monday of a month, in a given year, to find what day of that month it is.

Under the dominical letter of the year, and oppoſite to the month, look for the neareſt Sunday to the day propoſed, and from thence reckon to the day required.

2. What day of the month was the 2d Wedneſday of May 1787? *Anſ.* the 16th.

The dominical letter is G; then under G, and oppoſite to May, the 13th is the ſecond Sunday; and counting forward, the 2d Wedneſday is the 16th

3. What day of the week was the 7th July 1729? *Anſ.* Thurſday.

The dominical letter of 1729 is B. Under B, and oppoſite to July, the 3d day of the month was Sunday; then reckon 4 days forward, and July 7th is Thurſday.

4. What

4. What day of the week will be the 26th Auguſt 1809? *Anſ.* Saturday.

The dominical letter for 1809 is A.

Then under A, and oppoſite to Auguſt, the 27th is Sunday, and therefore the 26th is Saturday.

5. What day of the month will be the 3d Friday of December 1806? *Anſ.* the 19th.

The dominical letter for 1806 is E. Under E, and oppoſite to December, the 3d Sunday is the 21ſt of the month; and reckoning backward, the 3d Friday is the 19th.

PROB. *To find when Eaſter Sunday falls in any year until* 1899.

Eaſter Sunday is the firſt after the full moon, which happens on or next after the 21ſt of March; and therefore falls always between the 21ſt of March and the 25th of April.

Find the day of full moon on or next after the 21ſt March, and then find what day of the week the full moon is on, and the next Sunday is *Eaſter Sunday*.

EXAM. It is required to find *Eaſter Sunday* in the year 1798? *Anſ.* April 8.

The golden number is 13, which gives the time of mean new moon on March 17. in the Table, p. 64. and conſequently the time of the next mean full moon on April 2.

In 1798 the 2d of April is Monday, and the next Sunday is the 8th; therefore Eaſter Sunday is the 8th of April.

Beſides the annual epacts, there are monthly epacts, commonly called the *numbers of the months;* which are the moon's age on the firſt day of every month, when the ſolar and lunar years begin together, and are as below.

0	2	1	2	3	4
Jan.	Feb.	Mar.	Apr.	May.	June.
5	6	8	8	9	10
July.	Aug.	Sept.	Oct.	Nov.	Dec.

PROB.

PROB. VII. *To find the Moon's Age on any Day of a given Month.*

To the epact of the year add the number of the month and the day of the month; the ſum, if below 30, is the moon's age or number of days ſince the laſt conjunction; but if the ſum exceed 30, ſubtract 30 from it, and the remainder is the moon's age if the month has 31 days; but in months of 30 days ſubtract only 29.

EXAM. 1. What is the moon's age May 7th 1797?

Epact of the year - - -	1
Number of the mo. - -	3
Day of the month - -	7
Moon's age - - -	11 days.

The day of the next new moon is found by taking the moon's age from 30.

2. Required the moon's age Nov. 12th 1798?

Epact of the year - -	12
Number of the mo. - -	9
Day of the month - -	12
	33
Subtract - -	29
Moon's age - -	4 days.

The mean motion of the moon from the ſun in one day is 12° 11′ 2″, commonly reckoned only 12°. On the day of conjunction or new moon, the ſun and moon are on the meridian about the ſame time; but the next day, when the ſun is on the meridian, the moon is about 12° eaſtward of it, and therefore does not arrive at the meridian until about 48 minutes after the ſun: and the ſecond day the moon comes

to

to the meridian about 1 hour 36 minutes after the ſun; and ſo on every day 48 minutes later than on the former day.

The full moon comes to the meridian about midnight, and from thence to the change ſhe comes to the meridian in the forenoon. But 48 minutes is $\frac{4}{5}$ths of an hour; therefore,

PROB. VIII. *To find the time when the Moon comes to the Meridian any given Day.*

MULTIPLY the moon's age in days by 4, and divide the product by 5, the quotient is the hours, and the remainder multiplied by 12 is the minutes, when the moon comes to the meridian, reckoned from noon.

EXAM. 1. What time is the moon on the meridian May 7th 1797? *Anſ.* 8 h. 48 m.

Moon's age	- -	11
Multiply by	- -	4
		5)44(8h. 48m.

2. What time is the moon on the meridian Nov. 12. 1798? *Anſ.* 3h. 12m.

Moon's age	- -	4
Multiply by	- -	4
		5)16(3 h. 12m.

The regular riſe and fall of the ſea every 12 h. 24 m. is called the *tide.*

The tides at any place happen always when the moon is in the ſame poſition with reſpect to the meridian of that place: Thus if it be high water at any place when the moon is on the meridian of that place, it will be high water every day when the moon is on the meridian; and the ſame is true of every poſition of the moon. It is high water at Leith when the moon bears S. W. by S. or about 2 h. 15 m. after ſhe has

been on the meridian; and at London when the moon is S. W. or 3 hours paſt the meridian. Theſe times are found by obſervation; and there are tables of them in many books of navigation, and are called the times of high water on the days of new and full moon.

PROB. IX. *To find the time of High Water at any place on a given Day.*

FIND the time when the moon comes to the meridian on the given day, to which add the time of tide on the days of the new and full moon at that place, the ſum is the time of high water.

EXAM. 1. Required the time of high water at Leith May 7th 1797? *Anſ.* 11 h. 3 m. afternoon.

	h.	m.
Moon on the meridian at - -	8	48
Hour of tide on change days - -	2	15
	11	3

2. When will it be high water at London Nov. 12. 1798? *Anſ.* 6 h. 12 m.

	h.	m.
Moon on the meridian at - -	3	12
Time of tide on change days - -	3	0
	6	12

The ſolutions of the 7th, 8th, and 9th problems, are thoſe commonly given by authors who have treated of the ſubjects, and ſometimes give true anſwers. It muſt be acknowledged, however, that they are frequently wide of the truth; nor can it be otherwiſe, becauſe the lunar cycle, on which theſe ſolutions depend, is not perfectly true. For 235 mean lunations amount to 19 years 1 hour 28 minutes 5 ſeconds; therefore,

fore, after 19 years, the mean new and full moons happen on the ſame days of the month during the next cycle, but 1 h. 28 m. ſooner than they did in the former; and this ſeemingly ſmall error makes one day in 310 years.

Neither is the epact ſtrictly true; for the annual epact of 11 days is too great by 2 h. 48 m. 37 s. and therefore the moon's age deduced from it cannot be accurate: and an error in the moon's age muſt occaſion one in the time of her coming to the meridian, and conſequently in the time of high water or tide at any place.

But notwithſtanding of theſe defects, the rules are uſeful in the common buſineſs of life; for although the time of high water found by problems 8th and 9th may differ one half or even a whole hour from the true time, it gives the time ſo near, that a ſhip may ſail out of or into a harbour, and a boat may croſs a river or arm of the ſea, where there is a tide.

It may be obſerved that the time of high water depends ſo much on the winds and ſwell of the ſea at the time, that no rule of calculation can be given which will always produce a perfect anſwer.

The *Roman indiction* is a cycle of 15 years, uſed by the ancient Romans for the times of taxing the provinces. Three years of this cycle were elapſed at the beginning of the Chriſtian era.

PROB. *To find the Roman Indiction for any given Year.*

ADD 3 to the given year, and divide the ſum by 15, the quotient is the number of cycles elapſed, and the remainder is the year of the preſent cycle.

EXAM.

EXAM. Required the Roman indiction in the year 1799?

Anſ. 2.

To . . . 1799
Add . . . 3

15)1802(120
2 remains.

The Roman indiction is uſed in chronology, but has no connection with aſtronomical matters.

If the ſolar cycle 28, the lunar cycle 19, and the Roman indiction 15, be multiplied together (28 by 19, and the product by 15), the product 7980 is the great hiſtorical cycle, called the *Julian period.*

Whatever numbers theſe three cycles are in any year, they cannot be the ſame in any other year until after 7980 years are elapſed. For example, in A. D 1797 the ſolar cycle is 14, the lunar 12, and the Roman indiction 15, they cannot be the ſame again until A. D. 9777.

In the firſt year of the Julian period, ſuppoſed to be 710 years before the creation of the world, the ſolar, lunar, and indiction cycles began together, each of them being 1; and as this cannot happen again until the expiration of 7980 years, chronologers make this period the univerſal meaſure of time, and date all remarkable events by its years.

Different nations reckon their time and date their tranſactions from different epochas. For example,

Some

	Years of the Julian period	Years before Christ.
Some date their events from the creation of the world, and suppose it to have happened - -	710	4004
Others from the deluge or Noah's flood	2366	2348
The Greeks from the beginning of their Olympiads, of 4 years each -	3938	776
The Romans from the building of Rome	3961	753
Some astronomers from Nabonassar King of Babylon - -	3967	747
Some historians from the death of Alexander the Great - -	4390	324
The Christians from the birth of Christ	4713	A. D.
The Mahometans from the flight of Mahomet from Mecca, called the *Hegira*	5335	622

To find what year of the Julian period any given year of Christ answers to. To the given year add 4713, and the sum is the year of the Julian period. Thus the year 1797 answers to 6510 of the Julian period.

To find what year of Christ a given year of the Julian period is. From the given year subtract 4713. The remainder is the answer. Thus the 6513th year of the Julian period is the year 1800 of Christ.

Note: The given year must be above 4713.

PRACTICAL

PRACTICAL ASTRONOMY.

CHAP. I.

Of Time as reckoned at different places. How to convert the Time at any place to that of another.

IT is noonday at any place when the meridian of that place passes through the centre of the sun, and midnight at the same time in all places which are in the opposite meridian: and because the diurnal motion of the earth round its axis is always from west to east, the meridians of places pass through the sun successively; those on the west following the more easterly; and therefore all places situated on the east of any given place will have noonday, and every other hour, sooner than it; and places on the west will have the same hours later. For example, Moscow is east of London, and therefore has noonday some time before noon at London; for the same reason London has noonday, and every other hour, sooner than places on the west of its meridian.

The difference of time between any two places is found by converting their difference of longitude into time, at the rate of 15° for an hour.

The following tables of mean motions, &c. are calculated for the meridian of the Royal Observatory at Greenwich, which is frequently called the *meridian of London*, as being near

near it; and wherever the meridian of London is mentioned in this Work, that of Greenwich is meant. The longitudes of places are reckoned from the ſame meridian; and therefore the longitude of any place converted into time, is the difference of time between the meridian of that place and that of Greenwich.

To find more eaſily the time at one place correſponding to the time at another, the longitudes of a few places are turned into time, and arranged in the Table, pages 3, 4; which may be extended at pleaſure.

PROB. I. *The Time at Greenwich being given, to find the Time at any other place in the Table.*

IF the time at any place in eaſt longitude be required, add the difference of meridians to the given time, the ſum is the time required; but if the place be in weſt longitude, ſubtract the difference of meridians from the time at Greenwich, the remainder is the time required.

EXAM. 1. When it is 3 hours afternoon at London, what time is it at Moſcow? *Anſ.* 5 h. 31 m.

	h.	m.	s.
Time at London - -	3	0	0
Difference of meridians E. - -	+ 2	31	1
Time at Moſcow P. M. - -	5	31	1

2. When it is 7 h. 5 m. 30 s. in the morning at London, what time is it at Quebec in North America? *Anſ.* 2 h. 25 m. 54 s. in the morning.

	h.	m.	s.
Time at London - - -	19	5	30
Difference of meridians W. - -	4	39	36
Aſtronomical time at Quebec -	14	25	54

3. When

3. When it is 1 h. 14 m. 26 s. P. M. at London, what time is it at Pekin in China? *Anſ.* 8 h. 59 m. 52 s. or 9 h. afternoon nearly.

	h.	m.	s.
Time at London P. M. - -	1	14	26
Difference of meridians E. - -	+ 7	45	26
Time at Pekin P. M. - -	8	59	52

Note: The aſtronomical days begin and end at noon; and when any hour in the forenoon is mentioned, 12 hours is to be added to it to bring it to the aſtronomical time: Thus 7 hours in the morning is 19 hours (as in Exam. 2.); and if in addition the ſum exceed 24, the exceſs only is to be ſet down; alſo in ſubtraction 24 hours is to be borrowed when neceſſary.

PROB. II. *The Time at any place in the Table being given, to find the Time at Greenwich.*

IF the place be in eaſt longitude, ſubtract the difference of meridians found in the Table from the given time, the remainder is the time at Greenwich; but if the place be in weſt longitude, add the difference of meridians to the given time, the ſum is the time at Greenwich.

EXAM. 1. When it is 6 h. 30 m. 25 s. A. M. at St Peterſburg, what time is it at London? *Anſ.* 4 h. 29 m. 12 s. in the morning.

	h.	m.	s.
Time at Peterſburg - -	6	30	25
Difference of meridians E. - -	— 2	1	13
Time at London - -	4	29	12

2. What time is it at London when it is 5 h. 49 m. in the morning

morning at Quebec in North America? *Anſ.* 10 h. 28 m. 36 s. in the morning.

	h.	m.	s.	
Time at Quebec -	5	49	0	
Difference of meridians W.	+ 4	39	36	
Time at London -	10	28	36	in the morning.

3. When it is 3 h. 30 m. afternoon at Edinburgh, what time is it at Greenwich? *Anſ.* 3 h. 42 m. 25 s.

	h.	m.	s.	
Time at Edinburgh - -	3	30	0	P. M.
Difference of meridians W. -	+	12	25	
Time at Greenwich - -	3	42	25	P. M.

To reduce Degrees and Minutes of the Equator to Time.

Divide the given number of degrees by 15; the quotient is hours; and the remainder, reduced to minutes and divided by 15, gives the minutes, &c. Or,

Multiply the given number of degrees and minutes by 4, and divide the degrees in the product by 60, the quotient is hours, and the remainder minutes.

Exam. 1. It is required to reduce 37° 23′ of the equator to time?

15)37° 23′(2 h. 29 m. 32 s.

Or thus, 37° 23′

Multiplied by 4

Anſwer 2 h. 29 m. 32 s.

2. Reduce 171° 12′ 29″ to time.

4

Anſwer 11 h. 24 m. 49 s. 56‴

PROB. III. *The Longitudes of any two places, with the Time at one of them, being given, to find the corresponding Time at the other.*

FIND the difference of their longitudes, reduce it to time, and apply it to the given time by the former rules.

EXAM. 1. When it is noonday at Rome, what is the time at Conſtantinople? *Anſ.* 1 h. 6m. 23s. P. M.

		°	′	″
Conſtantinople, Longitude E.	-	28	53	0
Rome, Longitude E.	-	12	17	15
Difference	-	16	35	45
				4

Difference of meridians in time - 1 h. 6m. 23s. 0‴

		h.	m.	s.
Time at Rome	-	0	0	0
Difference of meridians E.	+	1	6	23
Time at Conſtantinople	-	1	6	23 P. M.

2. When it is 2 h. 3m. 30s. P. M. at Bengal in India, what time is it at Boſton in North America? *Anſ.* 3 h. 10m. 2s. in the morning.

		°	′	
Bengal, Longitude E.	-	92	45	} Add.
Boſton, Longitude W.	-	70	37	}
Difference of Longitude	-	163	22	
			4	

Difference of meridians in time - 10 h. 53m. 28s.

		h.	m.	s.
Time at Bengal	-	2	3	30
Difference of meridians W.	-	— 10	53	28
Aſtronomical time at Boſton	-	15	10	2

or 3 h. 10m. 2s. in the morning.

3. When

3. When it is 7h. 20m. 15s. in the forenoon at Gibraltar, what time is it at Hamburgh? *Anſ.* 8h. 21m. 51s. in the morning.

		°	′
Hamburgh, Longitude E.	- -	10	38
Gibraltar, Longitude W.	- - +	4	46
Difference of Longitude	- -	15	24
			4
Difference of meridians E.	- -	1h. 1m. 36s.	

	h.	m.	s.
Time at Gibraltar - -	7	20	15
Difference of meridians E. - +	1	1	36
Time at Hamburgh - -	8	21	51

CHAP. II.

Of the Equation of Time.

APPARENT TIME, called alſo *true time*, is that ſhown by a *ſun-dial*, or it is reckoned by the apparent motion of the ſun; the day being the interval between the time when the ſun's centre is on the meridian and his next return to it. This ſpace of time is the natural or ſolar day. A common year conſiſts of 365 of them, but they are not equal.

Mean time is that which is ſhown by a well-regulated clock. In this kind of time the days are all equal, each of them being the 365th part of a common year; and every day conſiſts of 24 equal parts called *hours*, and theſe are divided into minutes, &c.

The apparent and mean time never coincide but on four days in the year; *viz.* the 15th of April, the 15th of June, the

the 31ſt of Auguſt, and the 24th December, when they are nearly the ſame. At all other times the apparent differs from the mean.

The equation of time is the difference between the apparent and mean time, and ariſes from two cauſes, namely, the obliquity of the ecliptic, and the unequal motion of the earth in it.

By the obliquity of the ecliptic, the daily motions of longitude and right aſcenſion are unequal: for in the firſt and third quadrants of the ecliptic, the right aſcenſion is leſs than the longitude; and therefore the point of right aſcenſion on the equator being weſt of the point of longitude on the ecliptic, comes later to the meridian; and hence the apparent noon is then before the mean: but in the ſecond and fourth quadrants of the ecliptic, the right aſcenſion is greater than the longitude, and therefore the point of right aſcenſion on the equator being eaſtward of the point of longitude on the ecliptic, comes ſooneſt to the meridian; and hence the mean noon is before the apparent.

While the earth performs its annual revolution round the ſun in the ecliptic, it moves ſloweſt when at its greateſt diſtance from the ſun, called its *aphelion:* from that point round half of its orbit its motion is continually accelerated until it comes to its perihelion or point neareſt to the ſun; and from thence round the other half of its orbit, its velocity decreaſes continually until it arrives at its aphelion: on this account the natural days are unequal, as alſo their differences from the mean days. On theſe principles tables of the equation of time for every degree of the ſun's longitude, or for the noon of every day in the year, are calculated, Table, p. 19—22.

When the equation of time is required at any hour in a place eaſt or weſt from the meridian of Greenwich, the given time muſt be reduced to that meridian, and then the equation taken out for it.

PROB.

PROB. IV. *The Apparent Time being given to find the Mean Time, and the Mean being given to find the Apparent.*

TAKE the equation from the Table, p. 21. anſwering to the noon of the given day, and take alſo a proportional part for the hours if there be any; the ſum or difference of theſe will be the equation for the time: and then if the apparent time be given to find the mean, apply the equation to the given time according to its title; but if the mean time be given to find the apparent, apply the equation contrary to its title: the reſult is the anſwer.

EXAM. 1. When it is apparent noon at Edinburgh 10th Feb. 1795, what time is the mean noon?

	h.	m.	s.
Apparent time, civil account - -	12	0	0
Feb. 10. at noon, equation - -	+	14	41
Anſwer - - -	12	14	41

2. When it is 1 hour in the morning apparent time on the 6th December, required the mean time? *Anſ.* 0h. 51m. 22s. in the morning, civil time.

	m.	s.
December 5th at noon, the equation is -	8	52
6th - - - -	— 8	26
Difference - -	0	26

h. s. h. s.
As 24 : 26 : : 13 : 14 to be ſubtracted, becauſe the equation is decreaſing.

	m.	s.
From the equation on the 5th -	— 8	52
Subt. for 13 hours - -	— 0	14
Equation for the given time - -	— 8	38

	h.	m.	s.	
Apparent time -	13	0	0	
Equation - -	—	8	38	
Anſwer - -	12	51	22	mean time.

3. When

3. When it is 9h. 20m. 30s. P. M. at London on the 20th October 1795, mean time, required the apparent time? *Anſ.* 9h. 35m. 40 s.

	m.	s.	
Octob. 20. the equation is -	15	7	increaſing.
Prop. part for 9h. add -	+ 3		
Equation - -	— 15	10	

	h.	m.	s.
Mean time - -	9	20	30
Equat. its ſign changed -	+	15	10
Apparent time - -	9	35	40

4. When it is apparent noon at Pekin in China Octob. 29. 1795, what is the mean time at London?

	m.	s.
Octob. 28. Equation -	16	3
For 16 hours - -	+ 3	
Equation of time -	— 16	6

	D.	h.	m.	s.
Apparent time at Pekin in October -	29	0	0	0
Difference of meridians E. -	—	7	45	26
Apparent time at London -	28	16	14	34
Equation of time - -		—	16	6
Mean time at London -	28	15	58	28

That is, when it is apparent noon at Pekin October 29th, it is 3h. 58m. 28s. in the morning at London mean time.

5. May

5. May 15th, when it is 3 h. 30m. P. M. apparent time at Halifax in North America, what is the mean time at London?

	h.	m.	s.	
Apparent time at Halifax -	3	30	0	P. M.
Difference of meridians W. -	+ 4	13	20	
	7	43	20,	
May 15th, equation of time -	—	4	1	
Mean time at London - -	7	39	19	P. M.

The equations of time fitted to every day in the year, which we have uſed, are not always preciſely accurate, nor do they ſerve above 50 years without ſome correction. The other Table, anſwering to every degree of the ſun's longitude, is rather better; but either of them are ſufficient for common uſe: and when great accuracy is required, calculate the ſun's mean longitude, as hereafter taught, and alſo his true right aſcenſion for the time; the difference of theſe turned into time, at the rate of 15° per hour, is the true equation of time.

CHAP. III.

Concerning the Tables of Mean Motion.

THERE are two kinds of motion aſcribed to every planet in the ſolar ſyſtem, namely, mean motion and true. We ſpeak alſo of the motion of the ſun; but this is only apparent, ariſing from the motion of the earth in its orbit; for wherever the earth is in the ecliptic, we who are on its ſurface will ſee the ſun in the oppoſite point of the ſame circle.

For

For example, if the earth be in the ſign ♈, the ſun will appear in ♎; and when the earth has moved through any part of its orbit in a certain time, the ſun will ſeem to have paſſed through an equal ſpace in the oppoſite part of the ſame circle; and therefore, when the ſun is ſaid to move in the ecliptic, no more is meant than the motion of the earth.

Mean motion of a planet ſuppoſes its orbit to be a circle, and that the planet moves equably in it, or paſſes over equal ſpaces in equal times; and although none of the planets move equably in perfect circles, it has been found convenient to retain the hypotheſis, and to make tables of mean motion for every one of them.

To make a table of the mean motions of any planet, find out the time wherein the planet makes a complete revolution round the ſun, called its *period*; and then, as this time is to 12 ſigns or 360°, ſo is a year of 365 days to its mean motion in a year. In the ſame manner the mean motion for one day may be found. Multiply the mean motion for a year by 2 and by 3, and the motion for 1, 2, and 3, years will be known. To the 3d year's motion add the motion for 1 year and 1 day, the ſum is the mean motion for the 4th year; and ſo on as far as the table is to go, adding always one day's motion to every 4th or biſſextile year.

To make a table of the mean motion of the earth, commonly called the *mean motion of the ſun*.

A mean ſolar year is that ſpace of time wherein the ſun appears to move round the whole ecliptic, which conſiſts of 365 days 5 hours 48 minutes 54¾ ſeconds. A common year conſiſts of 365 days; and therefore, to find the ſun's mean motion for a common year, uſing decimals, we have,

As 365.2423 days
Is to 12 ſigns or 360°;
So is a year of 365 days
To 11.9920392 ſigns.
Or 11 s. 29° 45′ 40″ 14‴, the mean motion in 365 days.

To

To calculate the ſun's mean motion for a day.

As 365.2423d. : 360° : : 1d. : 0.985647°, or 59′ 8″ 19‴ 45⁗.

Having the ſun's mean motion for one day = 59′ 8″ 19¼‴, his motion for any number of days may be found by multiplication; and for any part of a day, as an hour or a minute, by diviſion.

To make a table of the ſun's mean longitudes for the current years of any epocha, we muſt know his longitude, as alſo that of the apogee for ſome particular time, ſuch as the time he entered into the ſign ♈ in a given year; and from thence compute his mean longitude on the 31ſt December at noon; for that is the beginning of January in the aſtronomical account, and his mean longitude then is reckoned for the following year; from which ſubtract the longitude of the apogee, the remainder is the mean anomaly. Now having the ſun's mean longitude and anomaly for any year, we can find them for any future or former year, by adding or ſubtracting the mean motions for the interval taken from the Table of complete years, p. 5.

PROB. V. *To calculate the true Longitude of the Sun for any given time and place by the Tables*, p. 6—13.

WHEN the given time is apparent, reduce it to mean time by Prob. IV. and if the given place be not in the meridian of the Tables, reduce it to that meridian by Prob. II. and then write down the years, months, days, hours, &c. under one another in a column on the left hand.

Take out of the Tables, p. 6—13. the ſun's mean longitude and anomaly, anſwering to each part of the time, and write them down on the right hand of the former numbers; then add them as they ſtand in their ſeveral columns, rejecting 12 ſigns, or any multiple thereof, and the ſum will be the mean longitude of the ſun for the given time.

To reduce the mean longitude to the true: Enter the

Table, p. 14. with the ſun's mean anomaly, and take out the equation of the centre, making proportion for the odd minutes, &c. and if the ſign of the ſun's mean anomaly be at the head of the Table, ſubtract the equation from the mean longitude; but if it be at the foot of the Table, add it to the mean longitude, and the true longitude of the ſun will be had.

EXAM. 1. Required the ſun's longitude 1796, Feb. 19. 11h. 21m. 30s. in the forenoon, apparent time, in the meridian of Edinburgh?

		D.	h.	m.	s.
Given time February	-	18	23	21	30
Edinburgh meridian W.	-	+		12	25
Equation of time	-	+		14	14
Mean time at Greenwich	-	18	23	48	9

	M. Long.				M. Anom.			
	S.	°	′	″	S.	°	′	″
1796 - -	9	10	51	52	6	1	23	42
Feb. 18. biſſex. -	1	17	18	40	1	17	18	31
23h. - -			56	40			56	40
48m. - -			1	58			1	58
9s. -	10	29	9	10	7	19	40	51
Equation of the centre	+ 1	28	30					
Sun's true longitude	11	0	37	40				

2. Re-

2. Required the sun's longitude 1795, June 22. at noon, apparent time, at Greenwich?

	h.	m.	s.
Mean time - -	0	0	0
Equation of time - -	+ 1	28	
	0	1	28

	M. Long.				M. Anom.			
	S.	°	′	″	S.	°	′	″
1795 -	9	10	7	2	6	0	39	58
June 22. -	5	20	31	1	5	20	30	30
0 h. 1 m. -				2				2
28″ -				1				1
	3	0	38	6	11	21	10	31
Equation of the centre		+	17	23				
Sun's true longitude	3	0	55	29				

3. It is required to find the sun's longitude 1797, May 15. 7h. 20m. P. M. apparent time, in the meridian of the island Bermuda?

	D.	h.	m.	s.
May - - -	15	7	20	0
Diff. merid. W. - -		+ 4	14	8
	15	11	34	8
Equation of time -			— 4	1
Mean time at Greenwich -	15	11	30	7

	M. Long.				M. Anom.			
	S.	°	′	″	S.	°	′	″
1797 -	9	10	37	33	6	1	8	17
May 15. -	4	13	3	45	4	13	3	21
11 h. -			27	6			27	6
30m. -			1	14			1	14
7s.								
	1	24	9	38	10	14	39	58
Equation of the centre		+ 1	21	3				
Sun's true longitude	1	25	30	41				

4. Re-

4. Required the ſun's longitude, 1800 Nov. 12. at 3 hours afternoon, in the meridian of Rome, apparent time?

	D.	h.	m.	s.
November - -	12	3	0	0
Diff. meridian E. -		—	49	49
Equation of time -		—	15	32
Mean time at Greenwich -	12	1	54	39

	M. Long.				M. Anom.			
	S.	°	′	″	S.	°	′	″
1800 -	9	9	54	35	6	0	21	1
Nov. 12. -	10	11	27	52	10	11	26	55
1 h. -			2	28			2	28
54m. -			2	13			2	13
39 s. -				1				1
	7	21	27	9	4	11	52	38
Equation of the centre	—	1	27	19				
Sun's true longitude	7	19	59	50				

In this example the mean anomaly is 4s. 11° 52′ 38″. The Table containing the equations of the centre is made only to degrees. Now to find the part of the equation for 52′ 38″, take the difference between the equation for 4s. 11°, and that for 4s. 12°, which is 1′ 20″, and then by logiſtical logarithms.

	°	′	″	L. L.
As -	1	0	0	0
Is to - -	0	1	20	1.6532
So is - -	0	52	38	569
To - -	—	1	10	
	1	28	29	1.7101
Equation -	1	27	19	

The part of the equation 1′ 10″ is ſubtracted from 1° 28″ 29″, anſwering to 4s. 11°, becauſe the equations are decreaſing.

5. What

5. What is the sun's longitude 1797, Sept. 3. 9h. 40m. in the forenoon, apparent time, at Peterſburg in Ruſſia?

	D.	h.	m.	s.
September - -	2	21	40	0
Difference of meridians E. -	—	2	1	13
Equation of time -	—			56
Mean time at Greenwich -	2	19	37	51

	M. Long.				M. Anom.			
	S.	°	′	″	S.	°	′	″
1797 -	9	10	37	33	6	1	8	17
Sept. 2. -	8	1	29	1	8	1	28	17
19h. -			46	49			46	49
37m. -			1	31			1	31
51s. -				2				2
	5	12	54	56	2	3	24	56
Equation of the centre			1	42	26			
Anſ. ſun's longitude	5	11	12	30				

6. Required the ſun's longitude 1797, Octob. 20. 10h. 20m. P. M. apparent time, at Quebec in North America?

	D.	h.	m.	s.
October - -	20	10	20	0
Diff. meridians W. -	+	4	39	36
	20	14	59	36
Equation of time -	—		15	7
Mean time at Greenwich -	20	14	44	29

	M. Long.				M. Anom.			
	S.	°	′	″	S.	°	′	″
1797 -	9	10	37	33	6	1	8	17
Oct. 20. -	9	18	47	41	9	18	46	48
14h. -			34	30			34	30
44m. -			1	48			1	48
29s. -				1				1
	7	0	1	33	3	20	31	24
Equation of the centre			1	49	9			
Anſ. ſun's longitude	6	28	12	24				

PROB.

PROB. VI. *The Mean Anomaly of the Sun being given, to find the Logarithm of his Diſtance from the Earth.*

WITH the mean anomaly of the ſun take out the logarithm of his diſtance from the earth from the Table, p. 15, 16.

EXAM. 1. Let the ſun's mean anomaly be 7s. 19° 40′ 51″, what is the logarithm of his diſtance from the earth?

For 7s. 19° the log. is	-	4.995224
For 40′ 51″ the part is	-	+ 69
Anſwer	-	4.995293

2. When the ſun's mean anomaly is 11s. 21° 10′ 31″, what is the logarithm of his diſtance? *Anſ.* 5.007203.

3. What is the logarithm of the ſun's diſtance from the earth when his mean anomaly is 4s. 11° 52′ 38″? *Anſ.* 4.995137.

PROB. VII. *To find the Apparent Semidiameter, and alſo the Hourly Motion of the Sun for any given Time.*

CALCULATE the ſun's mean anomaly for the given time, and with the mean anomaly of the ſun take out his ſemidiameter and hourly motion from the Table, p. 18.

EXAM. 1. Required the ſun's apparent ſemidiameter and hourly motion 1796, February 19th, 11 h. 21 m. in the forenoon?

The ſun's mean anomaly at that time is 7s. 19° 42′, which gives his ſemidiameter 16′ 13″ and his hourly motion 2′ 31″.

2. What is the ſun's apparent ſemidiameter and hourly motion 1795, June 22d, at noon?

The

The ſun's anomaly at that time is 11 s. 21° 10′, which gives his ſemidiameter 15′ 47″, and hourly motion 2′ 23″.

3. Required the ſun's apparent ſemidiameter and hourly motion 1800, at 1 h. 54 m. afternoon on the 12th day of November? *Anſ.* Apparent ſemidiameter 16′ 13″, and hourly motion 2′ 31″.

PROB. VIII. *The Longitude of the Sun, or any point of the Ecliptic, being given, to find the correſponding Right Aſcenſion.*

WITH the given longitude take the reduction out of the Table, p. 23, 24, and add it to or ſubtract it from the given longitude as the ſign ſhall direct; the ſum or remainder is the right aſcenſion.

EXAM. 1. Let the ſun's longitude be 11 s. 0° 37′ 40″, what is his right aſcenſion?

	S.	°	′	″
Longitude	11	0	37	40
Equation	+	2	4	0
R. A.	11	2	41	40
Or		332	41	40
In time	22 h.	10 m.	46 s.	

To find the part of the equation anſwering to 7′ 40″ by logiſtical logarithms.

	′	″	L. L.
As	30	0	3010
To	1	24	1.6320
So is	7	40	8935
			2.5255
			—3010
To	0	21	2.2245

S.	°	′		°	′	″
11	0	30	=	2	4	21
			—			21
Equation			+	2	4	0

2. When

2. When the sun's longitude is 3s. 0° 55′ 29″, what is his right ascension?

	S.	°	′	″		′	″	L. L.
Longitude	3	0	55	29	As	30	0	3010
Equation -		+	5	0	To	2	43	1.3441
					So	25	29	3719
R. A. -	3	1	0	29				
Or -		91	0	29				1.7160
In time	6h.	4m.	2s.		To	+ 2	18	1.4150
						+ 2	42	
					Equation	+ 5	0	

3. What is the sun's right ascension when his longitude is 1s. 25° 30′ 41″?

	S.	°	′	″
Longitude - -	1	25	30	41
Equation - -	—	2	20	34
R. A. - -	1	23	10	7
Or - -		53	10	7
In time - -	3h.	32m.	40s.	

4. The sun's longitude being 7s. 19° 59′ 50″, what is his right ascension?

	S.	°	′	″
Longitude - -	7	19	59	50
Equation - -	—	2	27	8
R. A. - - -	7	17	32	42
Or - - -		227	32	42
In time - - -	15h.	10m.	10s.	

PROB. IX. *The Right Aſcenſion of the Sun, or of any point in the Ecliptic, being given, to find the correſponding Longitude.*

WITH the right aſcenſion, increaſed by three ſigns, take the reduction out of the Table, as in the preceding problem, and apply it to the right aſcenſion, according to its ſign, and the longitude will be found.

EXAM. 1. Let the ſun's right aſcenſion be 11s. 2° 41′ 40″, what is his longitude?

	S.	°	′	″
R. A.	11	2	41	40
Reduction	—	2	4	0
Anſ. Longitude	11	0	37	40

R. A. increaſed by 3 ſigns is 2s. 2° 41′ 40″, to which, in the Table, the reduction is — 2° 4′ 0″.

2. The ſun's right aſcenſion being 3s. 1° 0′ 29″, what is his longitude?

	S.	°	′	″
R. A.	3	1	0	29
Reduction		—	5	0
Anſ. Longitude	3	0	55	29

R. A. increaſed by 3 s. is 6s. 1° 0′ 29″, to which the reduction is — 5′ 0″.

3. When the ſun's right aſcenſion is 7 s. 17° 32′ 42″, what is his longitude?

	S.	°	′	″
R. A.	7	17	32	42
Reduction		+ 2	27	7
Anſ. Longitude	7	19	59	49

R. A. increaſed by 3 s. is 10s. 17° 32′ 42″, to which the reduction is + 2° 27′ 7″.

4. Let the ſun's right aſcenſion be 1s. 23° 10′ 7″, what is his longitude?

		S.	°	′	″
R. A.	- -	1	23	10	7
Reduction	- -	+ 2	20	35	
Anſ. Longitude	- -	1	25	30	42

R. A. increaſed by 3s. is 4s. 23° 10′ 7″, to which the reduction is + 2° 20′ 35″.

To reduce time to degrees, multiply the hours, minutes, and ſeconds, by 15, and to the product add its half. The ſum will be degrees, minutes, and ſeconds of a circle.

5. Suppoſe the R. A. of a ſtar is 14h. 3m. 20s. what is its longitude? *Anſ.* 7s. 3° 2′ 28″.

h.	m.	s.		S.	°	′	″
14	3	20	R. A -	7	0	50	0
		15	Equation -	+ 2	12	28	
140	33	20	Longitude	7	3	2	28
½ 70	16	40					
210°	50′	0″, or 7s. 0° 50′ 0″.					

R. A. increaſed by 3s. is 10s. 0° 50′ 0″, to which the reduction is + 2° 12′ 28″.

PROB. X. *The Longitude of the Sun, or any point of the Ecliptic, being given, to find the correſponding Declination.*

WITH the given longitude take the declination out of the Table, p. 17.

EXAM.

EXAM. 1. Let the sun's longitude be 11 s. 0° 37′ 40″, what is his declination? *Anſ.* 11° 15′ 47″ ſouth.

To longitude 11 s. 0° the declination is 11° 29′ 5″ S. decreaſing; the difference between this and the next is 21′ 12″: Then,

	°	′	″	L. L.		°	′	″
As -	1	0	0	0				
To -	0	21	12	4518	From	11	29	5
So is -	0	37	40	2022	Subtract —	13	18	
To -	0	13	18	6540	Declinat.	11	15	47 S.

2. When the ſun's longitude is 3 s. 0° 35′ 29″, what is his declination?

To 3 s. 0° of longitude, the declination is 23° 28′ N. decreaſing. The difference between this and the next is 14″.

	°	′	″	L. L.		°	′	″
As -	1	0	0					
To -	0	0	14	2,4102	From	23	28	0
So is -	0	55	29	340	Subtract —		12	
To -	0	0	12	2.4442	Anſ. Decl.	23	27	48 N.

3. What is the ſun's declination when his longitude is 1 s. 25° 30′ 41″?

To longitude 1 s. 25° the declination is 19° 2′ 18″ N. increaſing. The difference between this and the next is 14′ 19″.

	°	′	″	L. L.		°	′	″
As -	1	0	0					
To -	0	14	19	1,6223	To	19	2	18
So is -	0	30	41	2912	Add	+	7	19
To -	0	7	19	9135	Anſ. Decl.	19	9	37 N.

4. When

4. When the sun's longitude is 7s. 19° 59′ 50″, what is his declination?

To longitude 7 s. 19° the declination is 17° 29′ 23″ S. increasing. The difference between this and the next is 16′ 17″.

		°	′	″				°	′	″
As	-	1	0	0	L. L.					
To	-	0	16	17	5664	To	-	17	29	23
So is	-	0	59	50	12	Add	-	+	16	14
To	-	0	16	14	5676	Anſ. Decl.		17	45	37 S.

PROB. XI. *The Time of the Year and the Sun's Declination being given, to find his Longitude; or the Declination of a Star, or of any point of the Ecliptic, being given, to find its Longitude.*

WITH the given declination take the longitude out of the ſame Table as in the preceding problem: Thus, take the declination in the Table neareſt leſs than that given, and write down the correſponding longitude; marking whether the declination be increaſing or decreaſing: then ſubtract the declination found in the Table from the next greater, the remainder is the difference of declination for 1° of longitude. Subtract alſo the declination found in the Table from that given; and then, as the difference of declination for 1° of longitude is to 1°, ſo is the difference between the given declination and that found in the Table to a part, to be applied to the longitude already found; the reſult is the true longitude.

EXAM. 1. February 19. 1706, the ſun's declination is 11° 15′ 47″ S. what is his longitude? *Anſ.* 11 s. 0° 37′ 39″.

1ſt, To declin. 11° 7′ 53″ S. the long. is 11 s. 1°, the declin. decreaſing.

	°	′	″
2d, From the given declin. -	11	15	47
Subtract the next leſs in the Table	11	7	53
Difference - -	0	7	54

3. Alſo

				°	′	″	
3d, Alſo from the next greater			-	11	29	5	
Subtract the next leſs in the Table				11	7	53	
Diff. declin. for 1° long.			-		0	21	12
				°	′	″	L. L.
4th, As	-	-		0	21	12	4518
To	-	-		1	0	0	0
So is	-	-		0	7	54	8805
To	-	-		0	22	21	4287

To be ſubtracted.

			S.	°	′	″
From the longitude found	-		11	1	0	0
Subtract the prop. part	-			—	22	21
There remains the true longitude			11	0	37	39

2. In the month of May, when the ſun's declination is 19° 9′ 37″ N. what is his longitude? *Anſ.* 1s. 25° 30′ 40″.

				°	′	″	
1ſt, Next greater declin.				19	16	37	
Next leſs	-			19	2	18	Long 1s. 25°.
Diff. declin. for 1° long.				0	14	19	declin. increaſing.
					°	′	″
2d, Given declination			-		19	9	37
Next leſs in the Table			-		19	2	18
Difference	-	-			0	7	19
				°	′	″	L. L.
3d, As	-	-		0	14	19	6223
To	-	-		1	0	0	0
So is	-	-		0	7	19	9138
To	-	-		0	30	40	2951

			S.	°	′	″
To the longitude found	-		1	25	0	0
Add the prop. part				+	30	40
True longitude	-		1	25	30	40

III. In

3. In the month of October, when the ſun's declination is 6° 44′ 14″ S. what is his longitude? *Anſ.* 6s. 17° 8′ 4″.

4. In the month of November, the ſun's declination being 17° 45′ 37″ S. what is his longitude? *Anſ.* 7s. 20° nearly.

PROB. XII. *The Longitude or Right Aſcenſion of the Sun, or of any point of the Ecliptic, being given, to find the Angle contained between the Ecliptic and the parallel to the Equinoctial paſſing through that point.*

IF the longitude be given, find the right aſcenſion, as in Prob. VIII. With the right aſcenſion ſo found or given, and increaſed by 3 ſigns, find the declination by Prob. X. as if the R. A. were longitude. This declination is the meaſure of the angle contained between the ecliptic and the parallel of declination; and if the declination is north, the ecliptic aſcends above the parallel; if ſouth, it deſcends below it.

EXAM. Let the right aſcenſion of the ſun be 3s. 1° 0′ 29″, required the angle which the ecliptic makes with the parallel of declination?

	S.	°	′	″
To the given R. A.	3	1	0	29
Add - -	3	0	0	0
To longitude -	6	1	0	29

the declination is 24′ 4″ S. which is the meaſure of the angle contained between the ecliptic and the parallel of declination at that time; and becauſe the declination is ſouth, the ecliptic deſcends below the parallel.

CHAP.

CHAP. VI.

Of the Moon's Motions. Computation of her Longitude and Latitude.

THE moon moves round the earth in an orbit more elliptical than the orbits of the primitive planets: the earth is in one of its foci, and the ſtraight line which paſſes thro' the foci is called the *line of the apſides*. The eccentricity of the moon's orbit is reckoned in this line, which at a mean is about $3\frac{1}{4}$ ſemidiameters of the earth. In one extremity of this line the moon is neareſt to the earth, called her *perigee*; and in the other ſhe is fartheſt from the earth, called her *apogee*. In thoſe points of her orbit which are equally diſtant from the foci, the moon is at her mean diſtance from the earth, which is about $60\frac{1}{4}$ of its ſemidiameter.

The moon's orbit is inclined to the ecliptic or earth's orbit in an angle of about $5\frac{1}{4}$ degrees. The interſections of the moon's orbit and ecliptic are called the *moon's nodes*; the moſt northerly is marked thus ☊, and the moſt ſoutherly ☋. While the moon moves forward in her orbit, in the order of the ſigns, her node moves ſlowly backwards, making a complete revolution round the ecliptic in about 225 days: but none of the moon's motions are truly equable; for her orbit itſelf and its eccentricity varies continually. Hence many equations are uſed to reduce the moon's mean motions to the true, in order to aſcertain her longitude and latitude.

Some

Some of the Moon's Periods.

THE moon goes once round her orbit from the firſt point of the ſign ♈ unto the ſame again in 27d. 7h. 43m. 5s. called her *periodical revolution.*

The moon moves from her node to the ſame again in 27d. 5h. 5m. 35s. which being leſs than her former period by 2h. 37m. 30s. ſhows that the moon's node moves backwards.

The moon moves from her *apogee* until her return to it in 27d. 13h. 18m. 34s. called her *anomaliſtic period;* and this being longer than her periodical revolution, ſhows that the apogee moves forward.

The moon's apogee makes an entire revolution from the vernal equinox to its return to it in 8 years 309 days 8 hours 20 minutes.

The moon's node moves backward from the vernal equinox until its return in 18 years 224 days 5 hours.

The moon moves from one conjunction with the ſun unto the next in 29d. 12h. 44m. 3s. called her *ſynodical revolution,* and ſometimes a lunation. All theſe periods are according to mean motions.

When the moon is in the ſame part of the heavens with the ſun, ſhe is ſaid to be in *conjunction,* vulgarly the time of new moon; and when ſhe is about 6 ſigns diſtant from the ſun, or riſes at ſun-ſetting, ſhe is in oppoſition, commonly called *full moon.* The conjunctions and oppoſitions are generally called the *ſyzygies.*

The moon's motion is nearly uniform about the time of new and full moons; at all other times it is affected with variable inequalities, particularly in the quadratures or in the middle between the conjunction and oppoſition; and moſt of all in the octants, which are equally diſtant from the ſyzygies and quadratures.

The

The face of the moon is called her *diſc*; which, although it is a ſpherical ſurface, appears flat on account of its diſtance. The ſun enlightens half of the lunar globe at all times, except when the earth intercepts the ſun's rays in the time of a lunar eclipſe. The ſtraight line which joins the centres of the ſun and moon is perpendicular to the moon's diſc, which is towards the ſun.

At the conjunction, the enlightened ſide of the moon being towards the ſun, her dark ſide is towards the earth, and therefore ſhe is then inviſible to us. In a ſhort time after the conjunction, a ſmall creſcent of the weſt ſide of the moon's diſc is luminous, which increaſes in breadth continually until it extends over the whole. When half the diſc is enlightened, the moon is in her firſt quarter; when the whole appears bright, ſhe is full; and after this, the enlightened part of her diſc decreaſes daily. When only the eaſtern half is enlightened, the moon is in her third quarter; and from thence her light decreaſes until ſhe is again inviſible at the conjunction.

PROB. XIII. *To calculate the true Longitude of the Moon for any given Time by the Tables.*

CALCULATE the true longitude of the ſun and his mean anomaly for the given time by Prob. V.

From the tables of the moon's mean motion, p. 29—43. take out the mean longitude, anomaly, and aſcending node, for the given year; under which write down the mean motions for the month, day, hours, &c.

Add the numbers in the columns of the mean longitude and anomaly, rejecting 12 ſigns or any multiples thereof when they occur; but from the longitude of the node for the given year ſubtract the ſum of all the numbers below it, borrowing 12 ſigns when neceſſary; and thus the moon's

mean longitude, mean anomaly, and the mean longitude of her node, will be obtained.

For the Arguments of the Equations.

The ſun's mean anomaly is the firſt argument. Subtract the true longitude of the ſun from the mean longitude of the moon, the remainder is the mean diſtance of the moon from the ſun, of which take the double.

To and from the double diſtance of the moon from the ſun add and ſubtract the firſt argument, the ſum and remainder are the ſecond and third arguments.

Add and ſubtract the moon's mean anomaly to and from the double diſtance of the moon from the ſun for the fourth and fifth arguments.

To and from the fifth argument add and ſubtract the firſt argument, and the ſixth and ſeventh arguments are found.

Subtract the firſt argument from the moon's mean anomaly, the remainder is the eighth argument.

Subtract the moon's mean anomaly from the moon's mean diſtance from the ſun, the remainder is the ninth argument.

Subtract the true longitude of the ſun from the mean longitude of the moon's node, and the remainder is the tenth argument.

With theſe arguments take the ſeveral equations out of the Tables, p. 44—48. and find their ſum.

With the mean anomaly of the ſun take out of the Tables, p. 44. the equations of the node and of the moon's mean anomaly. Apply the equation to the longitude of the node, and its equated longitude will be known. Correct the mean anomaly of the moon by its own equation, and alſo by the ſum of the ten former equations, and the correct anomaly of the moon will be had; which is the eleventh argument, with which

which take out of the Table p. 49, 50. the equation of the centre. Correct the mean longitude of the moon both by the ſum of the ten former equations and by the equation of the centre, and the equated longitude of the moon will be known.

Subtract the ſun's true longitude from the equated longitude of the moon, the remainder is the twelfth argument, with which take the variation out of the Table, p. 51. and apply it to the equated longitude of the moon.

Subtract the correct longitude of the node from the longitude of the moon twelve times corrected, and from double of the remainder ſubtract the moon's correct anomaly, the remainder is the 13th argument; with which take the thirteenth equation from the Table, p. 52. and apply it to the moon's longitude laſt found, which will give the moon's longitude in her orbit.

From the moon's longitude in her orbit ſubtract the correct longitude of the node, the remainder is the fourteenth argument; with which take out of the Table, p. 52. the reduction of the moon's place in her orbit to the ecliptic. And, laſtly, with the mean longitude of the moon's node take the equation of the equinoxes from the Table; and apply both the reduction and the equation of the equinoxes to the moon's longitude in her orbit, according to their ſigns, and the true ecliptic longitude of the moon will be found.

EXAM. 1. It is required to find the moon's longitude 1795, June 22. at noon, apparent time, in the meridian of Greenwich?

The equation of time is + 1m. 28s. therefore the mean time is oh. 1m. 28s.

Sun's longitude 3s. 0° 55′ 29″. Mean anomaly, 11s. 21° 10′ 31″.

	☽'s m. Long.				m. Anom.				☊			
	s.	°	′	″	s.	°	′	″	s.	°	′	″
1795 -	1	5	37	57	6	13	36	29	4	9	57	43
June 22. -	3	29	31	0	3	10	14	35				
oh. 1m. -				33				33	—	9	9	40
28s. - -				15				15				
	5	5	9	45	9	23	51	52	4	0	48	3
Sum of 10 eqs.		+	19	0		—	3	18		—	1	24
	5	5	28	45	9	23	48	34	4	0	46	39
Equat. centre		+	5	35	20		+	19	0			
☽'s equat. long.	5	11	4	5	9	24	7	34	= Arg. 11th.			
Variation -		+	20	48								
	5	11	24	53								
13th -			+	46								
☽'s orbit long.	5	11	25	39								
Reduction -		—	6	43								
	5	11	18	56								
Equinoxes -			—	15								
☽'s eclip. long.	5	11	18	41								

Equations.

	+		—	
	′	″	′	″
1			1	42
2			0	48
3			0	52
4	0	50		
5	20	36		
6			0	14
7			0	19
8			0	36
9	1	14		
10	0	51		
	+ 23	31	— 4	31
	— 4	31		
	+ 19	0		

Argu-

Arguments found.

		s.	°	′	″
☽	- -	5	5	9	45
☉	- -	3	0	55	29
☽ *à* ☉	-	2	4	14	16
Doubled	-	4	8	28	32
☉ Anom	±	11	21	10	31
2d =	-	3	29	39	3
3d =	-	4	17	18	1
		4	8	28	32
☽ Anom.	±	9	23	51	52
4th =	-	2	2	20	24
5th =	-	6	14	36	40
	±	11	21	10	31
6th =	-	6	5	47	11
7th =	-	6	23	26	9
		9	23	51	52
	—	11	21	10	31
8th =	-	10	2	41	21

Arguments found.

		s.	°	′	″
		2	4	14	16
	—	9	23	51	52
9th =	-	4	10	22	24
☊	-	4	0	48	3
☉	—	3	0	55	29
10th =	-	0	29	52	34
☽'s eq. long.		5	11	4	5
	—	3	0	55	29
12th =	-	2	10	8	36
☽'s long. equat.		5	11	4	5
☊	—	4	0	46	39
		1	10	17	26
Doubled	-	2	20	34	52
☽'s Anom.	—	9	24	7	34
13th =	-	4	26	27	18
☽ in orbit	-	5	11	25	39
☊	—	4	0	46	39
14th =	-	1	10	39	0

2. It

2. It is required to find the moon's longitude 1796, July 7th, 7h. 29m. 30s. P. M. apparent time, in the meridian of Edinburgh?

	D.	h.	m.	s.
July -	7	7	29	30
Diff. of merid.		+	12	25
Equat. of time		+	4	26
M. time at Green.	7	7	46	21

	s.	°	′	″
Sun's Long.	3	16	15	19
Mean Anom.	0	7	0	22

☽'s m. Long.	s.	°	′	″	m. Anom.	s.	°	′	″	☊	s.	°	′	″
1796 -	5	28	11	37		9	25	23	38		3	20	34	49
July 7. -	10	17	9	45		9	26	13	4					
7h. -			3	50	35			3	48	38		— 9	57	20
46m. -				25	15				25	2				56
21s. -					11					11				6
	4	19	37	23		7	25	50	33		3	10	36	27
Sum of 10 eq.			+ 13	5				+ 2	35				+ 1	6
	4	19	50	28		7	25	53	8		3	10	37	33
Equat. centre			+ 5	26	3			+ 13	5					
☽'s eq. long.	4	25	16	31		7	26	6	13	= 11th Arg.				
Variation -			+ 33	49										
	4	25	50	20										
13th equat. -			—	45										
☽'s orbit long.	4	25	49	35										
Reduction -			— 6	48										
	4	25	42	47										
Equinoxes -			—	18										
☽'s eclipt. long.	4	25	42	29										

Equations

Equations.

	+ ′ ″	− ′ ″
1	1 19	
2		0 53
3		1 5
4		0 48
5	15 7	
6		0 37
7		0 3
8		0 31
9	0 49	
10		0 13
	+17 15	4 10
	− 4 10	
	13 5	

Arguments found.

	S. ° ′ ″
☽ - -	4 19 37 23
☉ - -	3 16 15 19
☽ à ☉ -	1 3 22 4
Doubled -	2 6 44 8
Arg. 1st = ±	0 7 0 22
2d = -	2 13 44 30
3d = -	1 29 43 46
	2 6 44 8
Moon's An. = ±	7 25 50 33
4th = -	10 2 34 41
5th = -	6 10 53 35
= ±	0 7 0 22
6th = -	6 17 53 57
7th = -	6 3 53 13

Arguments found.

	S. ° ′ ″
Moon's Anom.	7 25 50 33
	— 0 7 0 22
8th = -	7 18 50 11
	1 3 22 4
	— 7 25 50 33
9th = -	5 7 31 31
☊ -	3 10 36 27
☉	— 3 16 15 19
10th = -	11 24 21 8
☽ - -	4 25 16 31
☉	— 3 16 15 19
12th = -	1 9 1 12
☽ - -	4 25 16 31
☊	— 3 10 37 33
	1 14 38 58
Doubled -	2 29 17 56
Moon's An.	— 7 26 6 13
13th = -	7 3 11 43
Moon's orbit	4 25 49 35
☊	— 3 10 37 33
14th = -	1 15 12 2

3. What

3. What is the moon's longitude 1797, Sept. 3d, 9h. 39m. in the forenoon, apparent time, at Peterſburgh?

	D.	h.	m.	s.	
Aſtronomical time, Sept. -	2	21	39	0	at Peterſburgh.
Difference of meridians -	— 2	1	13		
Equation of time -			— 54		
Mean time at Greenwich -	2	19	37	53	

	S.	°	′	″
Sun's longitude - -	5	11	12	30
Mean anomaly - -	2	3	24	56

Moon's M. Long.	S.	°	′	″	M. Anom.	S.	°	′	″	☊	S.	°	′	″
1797 -	10	7	34	43		0	24	6	53		3	1	15	6
Sept. 2. -	11	18	13	2		10	20	55	20					
19h. -		10	25	53			10	20	35		—12	58	26	
37m. -			20	19				20	8			2	31	
53s. - -				29					28				5	
	10	6	34	26		11	25	43	24		2	18	14	4
Sum of 10 eqs.		+1	22	28				+19	10				+8	8
	10	7	56	54		11	26	2	34		2	18	22	12
Equat. centre			+15	58			+1	22	28					
	10	8	12	52		11	27	25	2	= 11th Arg.				
Variation -			— 33	41										
	10	7	39	11										
13th equation			+1	22										
☽'s orbit long.	10	7	40	33										
Reduction -			— 6	43										
	10	7	33	50										
Equinoxes -			—	18										
☽'s eclipt. long.	10	7	33	32										

Equations.

Equations.

	+ ° ′ ″	— ′ ″
1	0 9 50	
2	0 0 6	
3	0 0 55	
4		0 16
5	1 12 29	
6		0 4
7		0 38
8		0 40
9	0 1 0	
10		0 14
	+1 24 20	1 52
	—0 1 52	
	1 22 28	

Arguments found.

	S. ° ′ ″
☽ - -	10 6 34 26
☉ - -	5 11 12 30
☽ à ☉ -	4 25 21 56
Doubled -	9 20 43 52
Arg. 1st, ±	2 3 24 56
2d = -	11 24 8 48
3d = -	7 17 18 56
	9 20 43 52
☽'s Anom. ±	11 25 43 24
4th = -	9 16 27 16
5th = -	9 25 0 28
Sun's Anom. ±	2 3 24 56
6th = -	11 28 25 24
7th = -	7 21 35 32

Arguments found.

	S. ° ′ ″
	11 25 43 24
	— 2 3 24 56
8th = -	9 22 18 28
	4 25 21 56
	— 11 25 43 24
9th = -	4 29 38 32
☊ -	2 18 14 4
	— 5 11 12 30
10th = -	9 7 1 34
☽ - -	10 8 12 52
☉ -	— 5 11 12 30
12th = -	4 27 0 22
☽ -	10 8 12 52
☊ -	— 2 18 22 12
	7 19 50 40
Doubled	3 9 41 20
	— 11 27 25 2
13th = -	3 12 16 18
☽'s orbit	10 7 40 33
☊ -	— 2 18 22 12
14th = -	7 19 18 21

4. Required the moon's longitude 1799, May 5th, 6h. P. M. apparent time, in the meridian of Edinburgh?

	D.	h.	m.	s.
Apparent time at Edinburgh, May -	5	6	0	0
Difference of meridians W. - -		+ 12	25	
Equation of time - -		— 3	35	
Mean time at Greenwich -	5	6	8	50

	S.	°	′	″
Sun's longitude - -	1	15	10	45
Mean anomaly -	10	4	4	13

	☽'s m. Long.				m. Anom.				☊			
	S.	°	′	″	S.	°	′	″	S.	°	′	″
1799 -	6	26	20	54	6	21	33	23	1	22	35	40
May 5th -	6	27	2	59	6	13	7	25				
6h. -		3	17	39		3	15	59	— 6	37	10	
8m. -			4	23			4	21				48
50s. -				27				27				1
	1	26	46	22	1	8	1	35	1	15	57	41
Sum of 10 equats.		+ 11		4		— 17	44			— 7	45	
	1	26	57	26	1	7	43	51	1	15	49	56
Equat. centre		— 3	40	20		+ 11		4				
	1	23	17	6	1	7	54	55	= 11th Arg.			
Variation -		+ 10		0								
	1	23	27	6								
13th equat. -			—	32								
☽'s orbit long.	1	23	26	34								
Reduction -		— 1	46									
	1	23	24	48								
Equinoxes -			—	13								
☽'s ecliptic long.	1	23	24	31								

Arguments.

	Arguments.				Equations.			
					+		−	
	S.	°	′	″	′	″	′	″
1	10	4	4	13			9	16
2	10	27	15	27	0	30		
3	2	19	7	1			1	14
4	2	1	12	49	0	50		
5	11	15	9	39	20	20		
6	9	19	13	52			1	56
7	1	11	5	26	0	30		
8	3	3	57	22	0	42		
9	11	3	34	2	0	36		
10	0	0	46	56	0	2		
12	0	8	16	21	+23	30	12	26
13	11	7	19	25	−12	26		
14	0	7	37	38				
					+11	4		

PROB. XIV. *The Moon's Longitude, Anomaly, and Node, being given, to find her Latitude by the Tables.*

SUBTRACT the corrected longitude of the moon's node from the moon's longitude in her orbit, the remainder is the firſt argument of latitude.

From the moon's longitude in her orbit ſubtract the ſun's longitude; and from double of the remainder ſubtract the firſt argument of latitude, the remainder is the ſecond argument.

Subtract the moon's mean anomaly from the firſt argument of latitude, and the remainder is the third argument.

From the third argument ſubtract the moon's mean anomaly for the fourth argument; alſo ſubtract the moon's mean anomaly from the fourth argument, and the remainder is the fifth argument.

With theſe arguments take out the numbers with their proper ſigns from the Tables, p. 53—55. and take the ſum of

of thoſe which are affirmative, and alſo the ſum of the negative; the difference of theſe ſums, with the ſign of the greater, will be the latitude of the moon; and will be north if marked with the ſign +, but ſouth if marked with the ſign —.

EXAM. 1. It is required to find the moon's latitude when her longitude in her orbit is 5s. 11° 25′ 39″, mean anomaly 9s. 23° 51′ 52″, and node 4s. 0° 46′ 39″? The ſun's longitude is 3s. 0° 55′ 29″.

Arguments found.					Equations.			
		s.	°	′	″		+	—
☽'s orbit lon.		5	11	25	39		° ′ ″	″
☊ -	—	4	0	36	39	1	3 21 48	
						2	0 8 40	
Arg. 1ſt =		1	10	49	0	3		16
						4		2
☽ -		5	11	25	39	5		16
☉ -	—	3	0	55	29			
							3 30 23	34
		2	10	30	10		— 34	
Doubled -		4	21	0	20		+ 3 29 49	
1ſt -	—	1	10	49	0			
2d = -		3	10	11	20			
1ſt - -		1	10	49	0			
☽'s Anom.	—	9	23	51	52			
3d = -		3	16	57	8			
	—	9	23	51	52			
4th = -		5	23	5	16			
	—	9	23	51	52			
5th -		7	29	13	24			

Anſ. The moon's latitude is 3° 29′ 49″ N.

2 What

2. What is the moon's latitude, her orbit longitude being 0s. 15° 50′ 46″, mean anomaly 4s. 27° 59′ 38″, and node 3s. 27° 8′ 51″?—Sun's longitude 5s. 9° 26′ 34″.

Arguments.		s.	°	′	″
1st =	-	8	18	41	55
2d =	-	5	24	6	29
3d =	-	3	20	42	17
4th =	-	10	22	42	39
5th =	-	5	24	43	1

Equations.	+ ′	+ ″	− °	− ′	− ″
1				5	2 46
2	0	54			
3				0	0 16
4	0	16			
5	0	2			
	+ 1	12	− 5	3	2
			+ 1	12	

Anſ. Moon's lat. — 5 1 50 S.

3. Required the moon's latitude, when her orbit longitude is 4s. 25° 49′ 35″, mean anomaly 7s. 25° 50′ 33″, and her node 3s. 10° 37′ 33″? Sun's longitude 3s. 16° 15′ 19″.

Arguments.		s.	°	′	″
1	1	15	12	2	
2	1	3	56	30	
3	5	19	21	29	
4	9	23	30	56	
5	1	27	40	22	

Equations.	+ °	+ ′	+ ″	−
1	3	39	1	
2	0	4	54	″
3				2
4	0	0	23	
5	0	0	12	
	+ 3	44	30	2
			− 2	

Anſ. Moon's lat. + 3 44 28 N.

4. What is the moon's latitude when her orbit longitude is 10s. 7° 40′ 33″, mean anomaly 11s. 25° 43′ 24″, and the true

true longitude of the node 2s. 18° 22′ 12″? Sun's longitude 5s. 11° 12′ 30″.

Arguments.	S.	°	′	″
1	7	19	18	21
2	2	3	37	45
3	7	23	34	57
4	7	27	51	33
5	8	2	8	9

Equations.	+ ′	+ ″	− °	− ′	− ″
1			3	54	2
2	7	54			
3	0	13			
4	0	19			
5			0	0	14
	8	26	− 3	54	16
			+ 0	8	26

Anſ. lat. - - - − 3 45 50 S.

The parallax of any celeſtial object is the angle contained between two ſtraight lines drawn from the centre of the object; one to the centre of the earth, and the other to any point of its ſurface. Or,

The true place of any celeſtial object is that which it would have if it were ſeen from the centre of the earth, and its apparent place is that which it ſeems to have when ſeen from any point on the earth's ſurface; and theſe two are the ſame when the object is in the zenith. In all other poſitions they differ more or leſs; and their difference, ariſing from the different poſitions of the eye, is called the *parallax of that object*. Hence it is eaſy to conceive that the true place is above the apparent, or that the parallax depreſſes the object below its true place.

The parallax of a ſtar is greateſt when the ſtar is in the horizon, and diminiſhes as its altitude increaſes, until it comes to the zenith, where it is nothing.

The parallaxes of different ſtars are greater or leſs, according as they are nearer to or farther from the earth.

The fixed ſtars have no ſenſible parallax. The ſun's parallax

rallax is very ſmall, not exceeding $8\frac{1}{2}$ or 9 ſeconds. The parallaxes of the primary planets are alſo ſmall, and not yet truly determined; but the moon being nearer to the earth than any other celeſtial object, her horizontal parallax is great in compariſon of any other ſtar, and extends from 54′ to 62′. Its magnitude depends on the moon's anomaly or diſtance from her apogee.

PROB. XV. *The Moon's Longitude, with the Arguments for finding it, being known, to find the Moon's equatorial Parallax or the horizontal Parallax of the Moon for any place on the Equator.*

WITH the 5th, 11th, and 12th arguments of longitude, take as many numbers from the Tables, p. 56, 57. with their proper ſigns; and from the ſum of the affirmative numbers ſubtract the ſum of the negative, the remainder is the moon's equatorial parallax, or the horizontal parallax of the moon to a place on the equator.

EXAM. 1. Let the moon's longitude be 5s. 11° 18′ 41″, and the arguments as below; required her equatorial parallax? *Anſ.* 56′ 5″.

	S.	°	′	″	+ ′	+ ″	− ″
5th Arg. -	6	14	36	40	0	36	
11th - -	9	24	7	34	55	49	
12th -	2	10	8	36			20
					+56	25	
					−	20	
Moon's equatorial parallax					56	5	

2. Let

2. Let the moon's longitude be 0s. 15° 47′ 53″; required her equatorial parallax? *Anſ.* 59′ 56″.

		s.	°	′	″	+ ′	+ ″	− ″
Arg. 5th	-	9	17	38	8			11
11th	-	4	29	41	24	59	58	
12th	-	7	5	49	3	0	9	
						+60	7	
						−	11	
Moon's equatorial parallax						59	56	

3. Let the moon's longitude be 4s. 25° 42′ 29″, what is her equatorial parallax?

		s.	°	′	″	+ ′	+ ″
Arg. 5th	-	6	10	53	35	0	37
11th	-	7	26	6	13	58	51
12th	-	1	9	1	12		4
Anſwer	-	-				59	32

PROB. XVI. *The Equatorial Parallax of the Moon being given and the Latitude of a place, to find the Horizontal Parallax of the Moon at that place; and to reduce the Apparent Latitude of the place to the centre of the Earth, ſuppoſing the Earth is an Oblate Spheroid.*

ENTER the Table, p. 57. with the given apparent latitude of the place on the ſide, and the equatorial parallax at the top, and making proportion, if neceſſary, find the reduction of parallax; which ſubtracted from the equatorial parallax, leaves the horizontal parallax required.

With the apparent latitude of the place take the reduction of latitude out of the ſame Table; which being ſubtracted from the apparent latitude, leaves the latitude reduced.

N. B. The horizontal parallax and latitude thus found are

are what ſhould be employed in computing the moon's parallaxes in longitude, latitude, and declination; which will now be performed by the common rules, founded on the ſuppoſition of the earth's being a ſphere.

EXAM. 1. Let the equatorial parallax be 56′ 5″, and the apparent latitude of the place 51° 28′ 40″; the moon's horizontal parallax and the reduced latitude of the place are required?

	′	″		°	′	″
Equatorial paralllax	56	5	Latitude -	51	28	40
Reduction -	—	9	Reduction -	—	14	42
Horizontal parallax	55	56	Reduced lat.	51	13	58

2. Let the equatorial parallax be 59′ 56″, and the latitude of the place 55° 58′; required the moon's horizontal parallax, and the reduced latitude of the place?

	′	″		°	′	″
Equatorial parallax	59	56	Latitude -	55	58	0
Reduction -	—	10	Reduction -	—	13	47
Horizontal parallax	59	46	Reduced lat.	55	44	13

3. Let the equatorial parallax be 54′ 9″, and the latitude of the place 59° 56′; required the moon's horizontal parallax and the reduced latitude?

	′	″		°	′	″
Equatorial parallax	54	9	Latitude -	59	56	0
Reduction -	—	10	Reduction -	—	12	56
Horizontal parallax	53	59	Reduced lat.	59	43	4

PROB. XVII. *The Equatorial Parallax being given, to find the Moon's horizontal Diameter.*

ENTER the Table, p. 58. with the moon's equatorial parallax, and take out her horizontal diameter.

For example, four of the moon's equatorial parallaxes, with the correſponding diameters, are put down below.

Moon's equatorial Parallaxes.	Moon's Diameters.
′ ″	′ ″
56 5	30 34
59 56	32 39
59 32	32 27
54 9	29 30

PROB. XVIII. *To find the Moon's Hourly Motion in Longitude; her Longitude in her Orbit, with the Arguments for finding it, being known.*

WITH the 5th, 11th, and 12th arguments of longitude, take out the numbers from the Tables, p. 59, 60.; the ſum of theſe, regard being had to their ſigns, is the moon's hourly motion in longitude.

EXAM. 1. Let the moon's longitude be 5s. 11° 25′ 39″, and the arguments as below; required her hourly motion in longitude?

		s. ° ′ ″	+ ′ ″	− ″
5th Arg.	-	6 14 36 40	0 41	
11th	-	9 24 7 34	31 20	
12th	-	2 10 8 36		31
			+32 1	
			− 31	
	Anſwer	-	31 30	

2. Re-

2. Required the moon's hourly motion in longitude, when her longitude is 0s. 15° 48′ 9″, and the arguments as under?

	S.	°	′	″	+ ′	+ ″	− ″
5th Arg. -	9	17	38	8			13
11th -	4	29	41	24	36	9	
12th -	7	5	49	3	0	13	
					+36	22	
					−	13	
Anſwer -					36	9	

PROB. XIX. *To find the Moon's Hourly Motion in Latitude, the Arguments for finding her Latitude being known.*

WITH the firſt and ſecond arguments of latitude, take two numbers out of the Tables, p. 60. their ſum if they have the ſame ſign, or their difference if they have contrary ſigns, is the moon's hourly motion in latitude; which tends to the north if it has the ſign +, but to the ſouth if it has the ſign −.

EXAM. 1. It is required to find the moon's hourly motion in latitude, the arguments of latitude being,

	S.	°	′	″	′	″
1ſt Arg. -	1	10	39	0	+2	15
2d - -	3	10	21	21	−	1
Anſwer -					+2	14 tending north.

2. What is the moon's hourly motion in latitude, the arguments for finding her latitude being,

	S.	°	′	″	″
1ſt -	8	18	41	55	− 44
2d - -	5	24	6	29	− 4
Anſwer -					−48 tending ſouth.

3. Re-

3. Required the moon's hourly motion in latitude, when the arguments are,

		S.	°	′	″		′	″
1ſt	- -	7	19	18	21	—	2	4
2d	- -	2	3	37	45	+	0	2
	Anſwer -					—	2	2 tending ſouth.

PROB. XX. *The Longitude and Latitude of the Moon, or of any Planet or Zodiacal Star, being given, to find its Right Aſcenſion and Declination; the Latitude not exceeding ſix Degrees.*

1. WITH the given longitude take the reduction of the ecliptic to the equator out of the Table, p. 23, 24. and apply it to the given longitude according to its ſign, the reſult is the right aſcenſion of the ecliptic place of the planet or ſtar.

With the ſign of the given longitude at the top or bottom of the Table, and the degree of longitude on the ſide; alſo the degree of latitude at the top or bottom of the Table, p. 62—66. take out the correction; which being applied to the ecliptic right aſcenſion, according to its ſign, will give the planet or ſtar.

2. With the given longitude take the declination out of the Table, p. 17. and this will be the declination of the ecliptic longitude of the planet or ſtar, which is north or ſouth according as the ſign is + or —.

If the latitude is of the ſame name with the declination, enter the Table, p. 68. but if it is of a contrary name, enter the Table p. 69. with the latitude at the top, and the ecliptic declination on the ſide, and take out a number; which in both caſes is to be ſubtracted from the given latitude; the remainder is the diminiſhed latitude. Then, if the latitude and declination are of the ſame name, the ſum of the diminiſhed latitude and ecliptic declination is the declination of the

the planet or ſtar; but if they are of contrary names, their difference is the declination.

EXAM. Let the moon's longitude be 5s. 11° 18′ 41″, and her latitude = 3° 29′ 9″ N.; required her right aſcenſion and declination?

For the moon's R. A.

	s.	°	′	″
1. To the given long. - - -	5	11	18	41
The reduct. p. 23d is - -		+ 1	27	3
Ecliptic R. A. - - -	5	12	45	44
Correction - - - -		+ 1	20	54
Moon's R. Aſcen. - -	5	14	6	38

2. For the reduction.

	°	′	″		°	′	″
Long.	5	11	0	gives	1	28	19
	5	11	30		1	26	17
				Difference	0	2	2

As 30′ : 2′ 2″ : : 18′ 41″ : 1′ 16″.

	°	′	″
From - - -	1	28	19
Subtract - -	— 1	16	
Reduction - -	+ 1	27	3

3. For the correction of R. Aſcen.

	s.	°	′	″		°	′	″
Long.	5	11	18	41	and lat. 4 gives		32	57
					3	1	9	31
					Difference	0	23	26

As 1° : 23′ 26″ : : 29′ 9″ : 11′ 23″.

	°	′	″
To - - - -	1	9	31
Add - -	+ 11	23	
Correction - - -	1	20	54

4. For

4. For the moon's declination.

To long. 5s. 11° 18′ 41″. Ecliptic declin. is 7° 20′ 2″ N.

For the correction of latitude.

	°	″	′	″	
Lat. 4 and declin.	7	20 gives	18	15	p. 68.
3			13	39	
Difference			4	36	

As 1° : 4′ 36′ : : 29′ 9″ : 2′ 14″.

	′	″
To - -	13	39
Add - -	2	14
Correction -	15	53

	°	′	″	
5. From the moon's lat. -	3	29	9	N.
Subtract the correction	—	15	53	N.
Diminiſhed lat. - - -	+ 3	13	16	N.
Ecliptic declin. add -	+ 7	20	2	N.
Moon' declin. N. - -	10	33	18	

2. Let the moon's longitude be 0s. 15° 50′ 46″, and her latitude 5° 1′ 50″ S. required her right aſcenſion and declination?

For the moon's R. A.

	S.	°	′	″	
1ſt, To the given longitude -	0	15	50	46	S.
The reduction is - -	—	1	15	10	
Ecliptic R. A. - -	0	14	35	36	
Correction - -	+	1	56	20	
Moon's R. A. - -	0	16	31	56	

2d, For the moon's declination.

To longitude 0s. 15° 50′ 46″, the ecliptic declination is 6° 14′ 32″ N.

	°	′	″	
3d, From the moon's latitude -	5	1	50	S.
Subtract the correction -	—	23	10	
Diminiſhed latitude - -	4	38	40	

4th, From

	°	′	″	
4th, From the ecliptic declination -	6	14	32	N.
Subtract diminiſhed latitude -	4	38	40	S.
Moon's declination N. -	1	35	52	

3. The moon's longitude being 5s. 23° 44′ 29″, and her latitude 4° 14′ 40″ N. it is required to find her right aſcenſion and declination?

For the moon's R. A.

	s.	°	′	″
1ſt, To the given longitude -	5	23	44	29
The reduction is -		+	30	46
Ecliptic R. A. -	5	24	15	15
Correction - -		+	1 41	28
Moon's R. A. - -	5	25	56	43

2. For the moon's declination.

To longitude 5s 23° 44′ 29″, the ecliptic declination is 2° 29′ 17″ N.

	°	′	″	
3. From the moon's latitude -	4	14	40	N.
Subtract the correction -		—	20	47
Diminiſhed latitude - -	3	53	53	

	°	′	″	
4. To the diminiſhed latitude -	3	53	53	N.
Add the declination -	2	29	17	N.
Moon's declination N. -	6	23	10	

4. What is the moon's right aſcenſion and declination when her longitude is 4s. 25° 42′ 29″, and latitude 3° 44′ 21″ N.?

	s.	°	′	″
Longitude - -	4	25	42	29
Reduction - - - -		+	2 15	18
Ecliptic R. A. - -	4	27	57	47
Correction - - -		+	1 18	58
Moon's right aſcenſion -	4	29	16	45

Ecliptic

Ecliptic declination 12° 57′ 53″ N.

	°	′	″
Latitude N.		3	44 21
Correction		— 13	35
Diminiſhed latitude		3	30 46
Ecliptic's declination	+ 12	57	53
Moon's declination N.	16	28	39

5. The longitude of the ſtar Aldebaran being 2 s. 6° 55′ 25″, and latitude 5° 28′ 51″ S. it is required to find its right aſcenſion and declination?

	S.	°	′	″
Longitude	2	6	55	25
Reduction		— 1	51	3
Ecliptic R. A	2	5	4	22
Correction			+ 57	22
R. Aſcen.	2	6	1	44

	°	′	″
Latitude S.	5	28	51
Correction		— 4	52
Diminiſhed latitude	5	23	59

	°	′	″
Ecliptic declination N.	21	29	26
Diminiſhed latitude	— 5	23	59
Declination	16	5	27 N.

CHAP

CHAP. VII.

Computation of the Longitudes and Latitudes of the Planets.

PROB. XXI. *To calculate the Longitude and Latitude of an inferior Planet for any given time and place.*

1. IF the given time be apparent, convert it into mean time by Prob. IV. and find the ſun's longitude for that time, as alſo the logarithm of the earth's diſtance from the ſun.

2. From the Tables of the planet's mean motion, p. 72. &c. collect the mean longitude of the planet, and of its apogee and node, for the ſeveral parts of the given time; write them down below each other, and find the ſums of the ſeveral columns, rejecting 12 ſigns, and writing down only the exceſs.

3. Subtract the mean longitude of the apogee from the mean longitude of the planet, and the remainder is its mean anomaly; with which take out the equation of the centre from the Table, and apply it to the mean longitude according to its ſign, and the reſult will be the heliocentric longitude of the planet in its orbit. With the ſame argument take out of the Table the logarithm of the planet's diſtance from the ſun.

4. Subtract the longitude of the node from the longitude of the planet in its orbit, the remainder is the argument of latitude; with which take out of the table the inclination of the planet's orbit to the ecliptic, or the heliocentric latitude; as alſo the reduction and the logarithm of curtation. Apply the reduction to the planet's orbit longitude

according to its ſign; and the heliocentric longitude of the planet in the ecliptic will be known. Subtract the logarithm of curtation from the logarithm of the planet's diſtance from the ſun; the remainder is the logarithm of the planet's curtate diſtance from the ſun.

5. Subtract the ſun's longitude from the heliocentric longitude of the planet; the remainder is the angle of commutation; take its half, and if the half exceeds 3 ſigns, take its complement to 6 ſigns.

6. Subtract the logarithm of the planet's curtate diſtance from the ſun from that of the earth's diſtance, and add the logarithm tangent of 45° to the remainder; the ſum is the tangent of an arch; from which ſubtract 45°, and to the tangent of the remainder add the tangent of the half commutation; the ſum (rejecting 10 from the index) will be the tangent of an arch; which being ſubtracted from half the angle of commutation, or from its ſupplement; the remainder will be the elongation of the planet from the ſun.

7. When the angle of commutation is leſs than 6 ſigns, add the elongation to the ſun's longitude; the ſum is the geocentric longitude of the planet; but when the angle of commutation exceeds 6 ſigns, ſubtract the elongation from the ſun's longitude; the remainder is the geocentric longitude of the planet.

Note. Heliocentric longitude or latitude of a planet is that which it would have if it was ſeen by an obſerver in the ſun; and geocentric is that which it ſeems to have when viewed by an obſerver on earth.

8. To find the geocentric latitude.

As the the ſine of commutation
Is to the ſine of elongation;
So is the tangent of inclination, or heliocentric latitude,
To the tangent of the geocentric latitude.

EXAM. 1. Let it be required to calculate the longitude and latitude of the planet Mercury, 1796, January 31ſt, at apparent noon, in the meridian of Greenwich?

The

The equation of time is + 13m. 43s. Take a day from the time, becauſe this is biſſextile year, and apply the equation; then the mean time is Jan. 30d. 0h. 13m. 43s.

At this time the ſun's longitude is 10s. 11° 27′ 11″. Log. of the earth's diſtance from the ſun 4.993686.

For Mercury's Longitude.

	m. Long.				Apogee.				Node.			
	S.	°	′	″	S.	°	′	″	S.	°	′	″
1796 -	8	13	19	58	8	14	17	6	1	15	53	55
Jan. 30d.	4	2	46	17	0	0	0	5	0	0	0	4
13m.	0	0	2	13								
43s. -	0	0	0	7	—8	14	17	11	— 1	15	53	59
	0	16	8	35	0	16	8	35	11	23	37	44
Equation	— 22	30	51		4	1	51	24	10	7	43	45
					m. Anom.				Arg. lat.			
Orbit long.	11	23	37	44								
Reduction		+ 12	24									
Eclipt. long.	11	23	50	8								
Sun's long. —	10	11	27	11								
Commut.	1	12	22	57								
Half -	0	21	11	28								
Sun's long.	10	11	27	11								
Elongation	+ 10	54	23									
Geoc. long.	10	22	21	34								

Log. - 4.554812
Curt. - —2021 Incl. S. 5° 31′ 20″

— 4.552791
Earth's ditto 4.993686

10.440895

° ′ ″
70 4 53
—45
25 4 53 tan. - 9.6702812
21 11 28 tan. - 9.5884913

— 10 17 5 tan. - 9.2587725
10 54 23 = elongation.

For

For the geocentric latitude.

		° ′ ″	
As fine commutation	-	42 22 57	9.8287001
To fine elongation	- -	10 54 23	9.2769324
So tan. heliocent. lat.	-	5 31 20	8.9853389
To tan. geocent. lat.	-	1 33 16	18.2622713
			8.4335712

	Longitude				Latitude S.		
	S.	°	′	″	°	′	″
Mercury's heliocentric	11	23	50	8	5	31	20
——— geocentric	10	22	21	34	1	33	16

2. It is required to find the longitude and latitude of mercury, 1797, April 28. at apparent noon, in the meridian of Edinburgh?

		D.	h.	m.	s.
Given time -	April	28	0	0	0
Difference of meridians	-		+ 12	25	
Equation of time -	-		+ 2	46	
Mean time at Greenwich		28	0	15	11

At this time the sun's longitude is 1 s. 8° 38′ 5″. Logarithm of earth's distance 5.003469.

For

For the longitude of Mercury.

m. Longitude.	s.	°	′	″	Apog.	s.	°	′	″	Node.	s.	°	′	″
1797 -	10	7	3	1		8	14	18	2		1	15	54	38
April -	0	8	18	50					14					11
28d. -	3	24	35	12					4					3
15m. -	0	0	2	33										
11s. -	0	0	0	2		—8	14	18	20		—1	15	54	52
	2	9	59	38		2	9	59	38		2	7	37	33
Equation	— 2	22	5			5	25	41	18		0	21	42	41
Orbit long.	2	7	37	33		m. Anom.					Arg. Lat.			
Reduct.		— 8	47											
Ecliptic long.	2	7	28	46										
Sun's long. —	1	8	38	5										
Commutation	0	28	50	41										
Half -	0	14	25	20										
Sun's long.	1	8	38	5										
Elongation	+ 6	37	24											
Geo. long.	1	15	15	29										

Log. - 4.488219
Curta. - — 444 Inclin. N. 2° 34′ 47″
— 4.487775
Earth's ditto 5.003469

°	′	″			
73	2	17	tan.	-	10.515694
—45					
28	2	17	tan.	-	9.7263899
14	25	20	tan.	-	9.4102206
—7	47	56	tan.	-	9.1366103
6	37	24	= elongation.		

For the geocentric latitude.

	°	′	″	
As S. commutation -	28	50	41	9.6834373
To S. elongation -	6	37	24	9.0619863
So tan. heliocentric lat. -	2	34	47	8.6537438
To tan. geocent lat. -	0	37	1	17.7157301
				8.0322928

Mercury's

	Long.				Lat. N.		
	S.	°	′	″	°	′	″
Mercury's heliocentric -	2	7	28	46	2	34	47
—— geocentric -	1	15	15	29	0	37	1

1. It is required to calculate the longitude and latitude of the planet Venus 1796, Feb. 13th, at apparent noon, in the meridian of Greenwich?

Take a day from the time for biſſextile year, and add the equation of time + 14m. 36s. to the remainder, and then the mean time at Grenwich is Feb. 12d. oh. 14m. 36s.

Sun's longitude is 10s. 24° 36′ 39″. Logarithm of Earth's diſtance is 4.994723.

For the Longitude of Venus.

m. Long.	S.	°	′	″	Apogee.	S.	°	′	″	Node.	S.	°	′	″
1796 -	10	25	59	38		10	8	33	0		2	14	50	4
Feb. -	1	19	40	2					4					3
12 d. -		19	13	34					2					1
14 m. -				56										
36 s. -				2		—10	8	33	6		— 2	14	50	8
	1	4	54	12		1	4	54	12		1	4	7	0
Equation		—	47	12		2	26	21	6		10	19	16	52
						m. anom.					arg. lat.			
Orb. long.	1	4	7	0										
Reduct. -		+	2	58										
Eclipt. long.	1	4	9	58										
Sun's lon. —	10	24	36	39										
Commut.	2	9	33	19										
Half -		34	46	39										
Sun's long.	10	24	36	39										
Elongation	+	28	38	39										
Geoc. long.	11	23	15	18										

Log.

Log. -		4.859552
Curt.		— 324 Inclin. S. 2° 12′ 31″.
		— 4.859228
Earth's dist.		4.994723
° ′ ″		
53 47 46	tan. -	10.135495
—45 0 0		
8 47 46	tan. -	9.189598 8
34 46 39	tan. -	9.841632 2
— 6 8 0	tan. -	9.031231 0

28 38 39 = elongation.

For the Geocentric Latitude of Venus.

	° ′ ″	
As S. commutation	69 33 19	9.971744 0
To S. elongation -	28 38 39	9.680669 6
So tan. heliocent. lat.	2 12 31	8.586211 7
To tan. geocentric lat.	1 7 49	18.266881 3
		8.295137 3

	Longitude.				Lat. S.		
	S.	°	′	″	°	′	″
Venus's heliocentric -	1	4	7	0	2	12	31
——— geocentric -	11	23	15	18	1	7	49

2. Required the longitude and latitude of Venus 1797, October 20th, 2 h. 30 m. P. M. apparent time, in the meridian of Glaſgow?

	D.	h.	m.	s.
Given time, October -	20	2	30	0
Difference of merid. W. -		+	16	20
Equation of time - -		—	15	13
Mean time at Greenwich -	20	2	31	7

Sun's long. 6s. 27° 42′. Log of Earth's dist. 4.997591.

For

For the Longitude of Venus.

m. Long.					Apogee.				Node.			
		S.	°	′	″	S.	°	′	″	S.	°	′	″
1797	-	6	10	47	8	10	8	33	49	2	14	50	35
Octob.	-	2	17	23	31				36				23
20d.	-	1	2	2	36				3				2
2h.	-			8	1								
31m.	-			2	4	—10	8	34	28	— 2	14	51	0
						10	0	23	20	10	0	30	1
		10	0	23	20								
Equation			+	6	41	11	21	48	52	7	15	39	1
						m. anom.				arg. lat.			
Orb. long.		10	0	30	1								
Reduction			—	3	0								
Eclipt. long.		10	0	27	1								
Sun's long.		—6	27	42	0								
Commut.		3	2	45	1								
Half	-		46	22	30								
		S.	°	′									
Sun's long.		6	27	42									
Elongation		+	1	7	9								
Geocent. long.		8	4	51									

Log. - 4.862325
Curtat. — 388 Inclin. S. 2° 25′ 20″.
— 4.861937
Earth's dist. 4.997591

°	′	″			
53	48	0	tan.	-	10.135654
—45	0	0			
8	48	0	tan.	-	9.1897939
46	22	30	tan.	-	10.0208526
—9	13	30	tan.	-	9.2106465

37 9 0 = elongation.

For

For the geocentric latitude.

As S. commutation	92 45 0		9.9994996
To S. elongation	37 9 9		9.7809677
So tan. heliocent. lat.	2 25 20		8.6263502
To tan. geocent. lat. S.	1 27 57		18.4073179
			8.4078183

	Longitude.				Lat. S.		
	S.	°	′	″	°	′	″
Venus's heliocentric	10	0	27	1	2	25	20
——— geocentric	8	4	51	0	1	27	57

PROB. XXII. *To calculate the Longitude and Latitude of a ſuperior Planet.*

THE firſt four articles of the rule for an inferior, anſwer equally well for a ſuperior planet.

5. Subtract the heliocentric ecliptic longitude of a ſuperior planet from the ſun's longitude, the remainder is the angle of commutation; of which take the half, and if the half exceed 3 ſigns take its complement to 6 ſigns.

6. Subtract the logarithm of the earth's diſtance from the ſun from the curtate logarithm of the planet's diſtance; add the logarithm tangent of 45° to the remainder; then from the number of degrees anſwering to the ſum, found in the Table of tangents, ſubtract 45°, and with the remainder and half of the commutation find out the elongation, as was done for an inferior planet.

7. When the angle of commutation is leſs than 6 ſigns, ſubtract the elongation from the ſun's longitude; and when it exceeds 6 ſigns, add the elongation to the ſun's longitude: the reſult is the geocentric longitude of the planet. The geocentric latitude of a ſuperior planet is found by the ſame rule as that of an inferior.

1. It is required to calculate the longitude and latitude of the planet Mars 1796, Feb. 13th, at apparent noon, in the meridian of Greenwich?

Becauſe the year is biſſextile, take away a day, and add the equation of time, and then the mean time is Feb. 12 d. 0 h. 14 m. 36 s.

Sun's longitude 10 s. 24° 36′ 39″. Log. of Earth's diſt. 4·994723.

For the Longitude of Mars.

m. Long.	s.	°	′	″
1796 -	6	7	25	42
Feb. -	0	16	14	46
12 d. - -		6	17	20
14 m. -				18
36 s. - -				1
	6	29	58	7
Equation -	—	8	26	59
Orbit long.	6	21	31	8
Reduct. -			+	43
Eclipt. long.	— 6	21	31	51
Sun's long.	10	24	36	39
Commut. -	4	3	4	48
Half -		61	32	24

	s.	°	′	″
Sun's long.	10	24	36	39
Elongation	— 2	25	19	18
Geocent. long.	7	29	17	21

Apogee.	s.	°	′	″
	5	2	19	46
				6
				2
	—5	2	19	54
	6	29	58	7
	1	27	38	13
m. anom.				

Node.	s.	°	′	″
	1	18	0	6
				2
				1
	—1	18	0	9
	6	21	31	8
	5	3	30	59
arg. lat.				

Log.

			Log. -		5.206336
			Curt. -		— 44 Inclin. N. 49° 30″.
					5.206292
			Earth's dist.		—4.994723
°	′	″			
58	26	4	tan. -		10.211569
—45	0	0			
13	26	4	tan. -		9.3781597
61	32	24	tan. -		10.2659589
+23	46	54	tan. -		9.6441186

85 19 18 = elongation.

For the Geocentric Latitude of Mars.

	°	′	″	
As S. commutation	123	4	48	9.9231970
To S. elongation	85	19	18	9.9985509
So tan. heliocent. lat.		49	30	8.1583613
To tan. geocentric lat.		58	52	18.1569122
				8.2337152

	Longitude.				Lat. N.	
	S.	°	′	″	′	″
Mars's heliocentric	6	21	31	51	49	30
—— geocentric	7	29	17	21	58	52

2. It is required to calculate the longitude and latitude of the planet Mars 1797, Decem. 1st, at apparent noon, in the meridian of Greenwich?

Equation of time — 10 m. 22 s.

	D.	h.	m.	s.
Given time, Dec. -	1	0	0	0
Equation of time - -			— 10	22
	0	23	49	38

Or Nov. 30d. 23h. 49m. 38s. mean time.

Sun's long. 8s. 9° 52′ 3″. Log. of Earth's dist. 4.998536.

For

For the Longitude of Mars.

m. Long.	s.	°	′	″	Apogee. s.	°	′	″	Node. s.	°	′	″
1797 -	0	18	42	52	5	2	20	53	1	18	0	34
Nov. -	5	9	19	4				56				23
30 d. -		15	43	20				5				2
23 h. -			30	8								
49 m. -			1	4	—5	2	21	54	—1	18	0	59
38 s. -				1	6	14	16	29	6	7	44	1
	6	14	16	29	1	11	54	35	4	19	43	2
Equation	— 6	32	28		m. anom.				arg. lat.			
Orbit long.	6	7	44	1								
Reduct. -			+ 53									
Eclipt. long. —	6	7	44	54								
Sun's long.	8	9	52	3								
Commut.	2	2	7	9								
Half -		31	3	34								
Sun's long.	8	9	52	3								
Elongation —	1	9	32	44								
Geocent. long.	7	0	19	19								

Log. - 5.213373
Curt. - — 95 Inclin. N. 1°11′46″.
5.213278
Earth's dist. — 4.993536

°	′	″			
58	54	50	tan.	-	10.219742
—45	0	0			
13	54	50	tan.	-	9.3939825
31	3	34	tan.	-	9.7797938
+ 8	29	10	tan.	-	9.1737763
39	32	44	= elongation.		

For

For the Geocentric Latitude of Mars.

	°	′	″	
As S. commutation	62	7	9	9.9464139
To S. elongation -	39	32	44	9.8039291
So tan. heliocent. lat.	1	11	46	8.3197120
To tan. geocent. lat.		51	41	18.1236411
				8.1772272

	Longitude.				Lat. N.		
	s.	°	′	″	°	′	″
Mars's heliocentric	6	7	44	54	1	11	46
—— geocentric	7	0	19	19	0	51	41

1. Required the longitude and latitude of the planet Jupiter 1797, July 11th, at apparent noon, in the meridian of Edinburgh?

	D.	h.	m.	s.
Given time July -	11	0	0	0
Difference of meridians		+	12	25
Equation of time		+	5	4
Mean time at Greenwich	11	0	17	29

Sun's longitude 3s. 19° 32′ 30″. Logarithm of Earth's distance 5.007172.

For

For the Longitude of Jupiter

m. Long.		Apogee.	Node.
	s. ° ′ ″	s. ° ′ ″	s. ° ′ ″
1797 -	11 21 12 48	6 11 11 5	3 8 53 0
July -	15 2 47	28	18
11 d. -	54 52	2	1
17 m. -	3		
		—6 11 11 35	—3 8 53 19
29 s. -	0 7 10 30	0 7 10 30	0 6 45 46
Equation -	— 24 44		
Orbit long.	0 6 45 46	5 25 58 55	8 27 52 27
Reduct. -	— 2	m. anom.	arg. lat.
Eclipt. long.	— 0 6 45 44		
Sun's long.	3 19 32 30		
Commut.	3 12 46 46		
Half -	51 23 23		
Sun's long.	3 19 32 30		
Elongation	—3 0 55 40		
Geocent. long.	0 18 36 50		

Log. - 5.694680
Curt. - — 115 Inclin. S. 1° 19′ 6″.

5.694565
Earth's dist. — 5.007172

° ′ ″			
78 23 34	tan.	-	10.687393
—45 0 0			
33 23 34	tan.	-	9.8190156
51 23 23	tan.	-	10.0976797
+39 32 17	tan.	-	9.9166953
90 55 40 = elongation.			

For

For the Geocentric Latitude of Jupiter.

	° ′ ″	
As S. commutation	102 46 46	9.9891352
To S. elongation	90 55 40	9.9999431
So tan. heliocent. lat.	1 19 6	8.3619793
To tan. geocentric lat.	1 21 5	18.3619224
		8.3727872

	Longitude.				Lat. S.		
	S.	°	′	″	°	′	″
Jupiter's heliocentric	0	6	45	44	1	19	6
—— geocentric	0	18	36	50	1	21	5

2. Required the longitude and latitude of the planet Jupiter 1798, December 7th, at apparent noon, in the meridian of Dublin? Lat. 53° 20′ N. Long. 6° 28′ W.

	D.	h.	m.	s.
Given time Decem. -	7	0	0	0
Difference of meridians W.		+	25	52
Equation of time -		—	7	59
Mean time at Greenwich	7	0	17	53

Sun's longitude 8s. 15° 44′ 15″. Logarithm of Earth's distance 4.993201.

For

For Jupiter's Longitude.

m. Long.	S.	°	′	″
1798 -	0	21	33	18
Decem. -		27	45	54
7 d. -			34	55
17 m. -				3
	1	19	54	10
Equation -	+ 3	37	17	
Orbit long.	1	23	31	27
Reduct. -			+	27
Eclipt. long. —	1	23	31	54
Sun's long.	8	15	44	15
Commut. -	6	22	12	24
Half -	3	11	6	12
Complem. -		78	53	48
Sun's long.	8	15	44	15
Elongation	+ 5	2	36	19
Geocent. long.	1	18	20	34

Apogee.	S.	°	′	″
	6	11	12	7
			52	
-			1	
	—6	11	13	0
	1	19	54	10
	7	8	41	10
	m. anom.			

Node.	S.	°	′	″
	3	8	54	0
				33
				1
	—3	8	54	34
	1	23	31	27
	10	14	36	53
	arg. lat.			

Log. - 5.699860
Curt. . — 59 Inclin. S. 56′ 22″.
5.699801
Earth's dist. —4.993201

°	′	″			
78	52	55	tan.	-	10.706600
—45	0	0			
33	52	55	tan.	-	9.8270555
78	53	48	tan.	-	10.7071834
+73	42	31	tan.	-	10.5342389

152 36 19 = elongation, or 5s. 2° 36′ 19″.

For

For Jupiter's Geocentric Latitude.

	° ′ ″	
As S. commutation	22 12 24	9.5774326
To S. elongation -	27 23 41	9.6628692
So tan. heliocent. lat.	56 22	8.2147874
To tan. geocent. lat. S.	1 11 33	17.8776566
		8.3002240

	Longitude.				Lat. S.		
	S.	°	′	″	°	′	″
Jupiter's heliocentric	1	23	31	54	0	56	22
——— geocentric	1	18	20	34	1	11	33

1. It is required to calculate the longitude and latitude of the planet Saturn 1797, April 1st, at apparent noon, in the meridian of Greenwich?

The equation of time is + 3 m. 46s. therefore the mean time is April 1 d. 0h. 3m. 46 s.

Sun's longitude 0s. 12° 14′ 55″. Log. of Earth's distance 5.000230.

For the Longitude of Saturn.

m. Long.	S.	°	′	″
1797 -	2	25	34	54
April -		3	0	53
1 d. -			2	1
4 m.				
	2	28	37	48
Equation		—	18	5
Orb. long.	2	28	19	43
Reduct. -		+	1	12
Eclipt. lon.	—2	28	20	55
Sun's long.	0	12	14	55
Commut.	9	13	54	0
Half -	4	21	57	0
Complem.		38	3	0
Sun's long.	0	12	14	55
Elongation	+2	10	5	48
Geoc. long.	2	22	20	43

Apogee.	S.	°	′	″
	9	1	5	0
				17
	—9	1	5	17
	2	28	37	48
	5	27	32	31
	m. anom.			

Node.	S.	°	′	″
	3	21	54	47
				8
	—3	21	54	55
	2	28	19	43
	11	6	24	48
	arg. lat.			

Log. - 5.954091
Curt. - —66 Inclin. S. 1° 0′ 4″.

5.954025
Earth's dist. —5.000230

°	′	″			
83	39	12	tan.	-	10.953795
—45	0	0			
38	39	12	tan.	-	9.9029893
38	3	0	tan.	-	9.8935909
+32	2	48	tan.	-	9.7965802
70	5	48	= elongation.		

For

For Saturn's Geocentric Latitude.

	°	′	″	
As S. commutation	76	6	0	9.9870924
To S. elongation	70	5	48	9.9732517
So tan. heliocent. lat. S.	1	0	4	8.2424038
To tan. geocent. lat. S.		58	11	18.2156555
				8.2285631

	Long.				Lat. S.		
	S.	°	′	″	°	′	″
Saturn's heliocentric	2	28	20	55	1	0	4
—— geocentric	2	22	20	43	0	58	11

2. It is required to calculate the longitude and latitude of the planet Saturn 1797, Auguſt 1ſt, at midnight, apparent time, in the meridian of Stockholm in Sweden; latitude 59° 22′ N. and longitude 18° 12′ E.?

	D.	h.	m.	s.
Given time Auguſt -	1	12	0	0
Difference of meridians E. -	—	1	12	48
Equation of time - -	+		5	53
Mean time at Greenwich -	1	10	53	5

Sun's longitude 4s. 10° 1′ 57″. Logarithm of Earth's diſtance 5.006241.

For

For Saturn's Longitude.

	m. Long.				Apogee.				Node.			
		S.	°	′	″	S.	°	′	″	S.	°	′	″
1797	-	2	25	34	54	9	1	5	0	3	21	54	47
Aug.	-		7	6	6				39				18
1d.	-			2	1								
10h.	-				50	—9	1	5	39	— 3	21	55	5
53m.	-				4	3	2	43	55	3	2	55	58
		3	2	43	55	6	1	38	16	11	11	0	53
Equation			+	12	3	m. anom.				arg. lat.			
Orb. long.		3	2	55	58								
Reduction			—	1	1								
Eclipt. lon.		—3	2	54	57								
Sun's long.		4	10	1	57								
Commut.		1	7	7	0								
Half	-		18	33	30								
Sun's long.		4	10	1	57								
Elongation		—1	3	32	35								
Geocent. lon.		3	6	29	22								

Log. - 5.954075
Curtat. — 44 Inclin. S. 48′ 53″.

5.954031
Earth's dist. —5.006241

°	′	″			
83	33	56	tan.	-	10.947790
—45	0	0			
38	33	56	tan.	-	9.9016090
18	33	30	tan.	-	9.5259873
+14	59	5	tan.	-	9.4275963

33 32 35 = elongation.

For

For Saturn's Geocentric Latitude.

	°	′	″	
As S. commutation	37	7	0	9.7806341
To S. elongation	33	32	35	9.7423721
So tan. heliocentric lat.		48	53	8.1529162
To tan. geocentric lat.		44	45	17.8952883
				8.1146542

	Long.				Lat. S.	
	S.	°	′	″	′	″
Saturn's heliocentric	3	2	54	57	48	53
—— geocentric	3	6	29	22	44	45

PROB. XXII. *The Geocentric Longitude and Latitude of any planet being given, to find its Right Aſcenſion and Declination.*

Work by the rule given in the ſolution of Prob. XX. p. 124.

EXAM. 1. It is required to find the right aſcenſion and declination of the planet Mercury, when his geocentric longitude is 10s. 22° 21′ 34″, and latitude 1° 33′ 16″ S.?

For the Right Aſcenſion.

	S.	°	′	″
1. To longitude	10	22	21	34
The reduction is		+ 2	22	7
Ecliptic right aſcenſion	10	24	43	41
Correction			+ 31	29
Right aſcenſion	10	25	15	10
Or		325	15	10
R. A. in time	21 h.	41 m.	0s.	

For

For correcting the Right Aſcenſion on account of the latitude.

	S.	°	′	″		°		′	″
2. Long.	10	22	21	34	with Lat.	2	gives	+ 40	33
								— 20	11
							Difference -	20	22

		′	″		L. L.
3. As	-	60	0	Lat.	0
To	-	20	22		4692
So	-	33	16	Lat.	2561
To	-	11	18		7253
Add	-	20	11		
		+ 31	29	= the correction	

For the Declination.

1. To long. 10s. 22° 21′ 34″ the ecliptic declin. is 14° 4′ 36″ S.

	°	′	″		°		′	″
2. Declin.	14	4	36	and Lat.	2	gives reduct. of lat.	6	35
							3	19
						Difference -	3	16

		′	″		L. L.
3. As	-	60	0	Lat.	0
To	-	3	16		12640
So	-	33	16	Lat.	2561
To	-	1	48		15201
Add	-	3	19		
Reduct.	-	5	7		

	°	′	″	
4. From the given latitude -	1	33	16	S.
Subtract the reduction -		— 5	7	
Diminiſhed latitude - -	1	28	9	S.
Add the ecliptic declination -	14	4	36	S.
Mercury's declination S. -	15	32	45	

Mercury's

Mercury's right aſcention in time = 21h. 41m.
and declination ſouth = 15° 32′ 45″.

2. When the geocentric longitude of Mercury is 1s. 15° 15′ 29″, and his latitude 37′ 1″ N.; required his right aſcenſion and declination?

For the Right Aſcenſion.

	S.	°	′	″
1. To longitude - -	1	15	15	29
The reduction is - -	—	2	28	18
Ecliptic right aſcenſion -	1	12	47	11
Correction - -	—		11	21
Right aſcenſion -	1	12	35	50
Or - -		42	35	50

In time 2h. 50m. 23s.

2. For correcting the Right Aſcenſion.

To long. 1s. 15° 15′ 29″, and lat. 1° the correct. is — 18′ 24″. In this example 18′ 24″ is alſo the difference.

	′	″		L.	L.
3. As -	60	0	Lat.	0	
To -	18	24		5133	
So -	37	1	Lat.	2098	
To -	11	21		7231	

For the Declination.

1. To long. 1s. 15° 15′ 29″, the ecliptic declination is 16° 25′ 46″ N.

2. To declination 16° 25′ 46″, and latitude 37′ 1″, the reduction is 2′ 39″.

3. From

	°	′	″	
3. From the given latitude N. -	0	37	1	
Subtract the reduction -	—	1	38	
Diminiſhed latitude	0	35	23	N.
Ecliptic declination -	+ 16	25	46	N.
Mercury's declination N. -	17	1	9	

The right aſcenſion of Mercury in time = 2 h. 50 m. 23 s. and his declination = 17° 1′ 9″ N.

Note. In this example the reduction of latitude was found thus:

To declin. 16° 25′ 46″, and lat. 1° the reduction is 2′ 39″.

Then, as 1° lat. : 2′ 39″ : : 37′ 1″ lat. : 1′ 38″ the reduct.

For when the planet's latitude is leſs that 1°, the reduction taken out of the Table, p. 68, 69, anſwering to 1° of latitude, is to be accounted the difference; becauſe the Table is made only for whole degrees.

3. It is required to calculate the right aſcenſion and declination of the planet Venus, her geocentric longitude being 11 s. 23° 15′ 18″, and latitude 1° 7′ 49″ S.?

For the Right Aſcenſion.

	S.	°	′	″
1. To longitude -	11	23	15	18
The reduction is - -		+ 33	13	
Ecliptic right aſcenſion -	11	23	48	31
Correction - - -		+ 26	54	
Right aſcenſion -	11	24	15	25
Or - - -		354	15	25

In time - 23 h. 37 m. 2 s.

For

For correcting the Right Aſcenſion.

	S	°	′	″		°	′	″
2. To long. 11	23	15	18, and lat. 2, the correct. is				47	38
———	———	———	———	———	lat. 1	———	23	48
					Difference	-	23	50

		′	″		L. L.
3. As	-	60	0	Lat.	0
To	-	23	50		4010
So	-	7	49	Lat.	8851
To	-	3	6		12861
Add	-	23	48		
Correct.		26	54		

For the Declination.

1. To long. 11 s. 23° 15′ 18″, the ecliptic declin. is 2° 40′ 51″ South.

	°	′	″		°	′	″
2. To declin. 2	40	51, and lat. 2, the reduction is				9	51
———	———	———	———	lat. 1	———	4	56
				Difference	-	4	55

		′	″		L. L.
3. As	-	60	0	Lat.	0
To	-	4	55		10865
So	-	7	49	Lat.	8851
To	-	0	38		19716
Add	-	4	56		
Reduction		5	34		

		°	′	″	
4. From the given latitude	-	1	7	49	
Subtract the reduction	-	—	5	34	
Diminiſhed latitude	- -	1	2	15	S.
Add the ecliptic declination	-	2	40	51	S.
Venus's declination	- -	3	43	6	S.

The right aſcenſion of Venus in time = 23h. 37m. 28.; and declination ſouth = 3° 43′ 6″.

4. Required the right ascension and declination of the planet Venus, when her geocentric longitude is 8s. 4° 51′, and latitude 1° 27′ 57″ south?

For the Right Ascension.

	s.	°	′	″
1. To longitude	8	4	51	0
The reduction is	—	1	57	21
Ecliptic R. A.	8	2	53	39
Correction	—		17	19
R. Ascension	8	2	36	20
Or		242	36	20
In time	16h.	10m.	25s.	

For correcting the right ascension.

	′	″
2. To long. 8s. 4° 51′, and lat. 2°, the correct. is	23	41
——————lat. 1——————	11	46
Difference	11	55

			′	″	L. L.
3. As	-	-	60	0 lat.	0
To	-	-	11	55	7020
So	-	-	27	57 lat.	3318
To	-	-	5	33	10338
Add	-	-	11	46	
Correct.	-	-	17	19	

For the declination.

1. To long. 8s. 4° 51′, the eclipt. decl. is 21° 7′ 41″ S.

2. To decl. 21° 7′ 41″, and lat. 2°, the reduct. is	2	1
——————lat. 1°,——————	1	1
Difference -	1	0

3. As

		′	″	L. L.
3. As	-	60	0 lat.	0
To	-	1	0	17782
So	-	27	57 lat.	3318
To	-	0	27	21100
Add	-	1	1	
Reduct.	-	1	28	

	°	′	″	
4. From the given lat. -	1	27	57	S.
Subtract the reduct. - -	—	1	28	
Diminiſhed lat. - -	1	26	29	S.
Add the ecliptic declin. -	21	7	41	S.
Venus's declination - - -	22	34	10	S.

The right aſcenſion of Venus in time = 16h. 10m. 25s. and declination ſouth = 22° 34′ 10″.

5. It is required to calculate the right aſcenſion and declination of the planet Mars; his geocentric longitude being 7s. 29° 17′ 21″, and latitude 58′ 52″ N.?

For the Right Aſcenſion.

	s.	°	′	″
1. To longitude - -	7	29	17	21
The reduction is - -	—	2	12	58
Ecliptic R. A. - -	7	27	4	23
Correction - -	+		13	26
R. aſcenſion - -	7	27	17	49
Or - - -		237	17	49
In time - -	15h.	49m.	11s.	

2. For

For correcting the R. Ascension.

2. To long. 7s. 29° 17′ 21″, and lat. 1°, the correct. is 13′ 42″.

					L. L.
3. As	-	60	0	lat.	0
To	-	0	13	42	6414
So	-	1	58	52 lat.	83
To	-	1	13	26	6497

For the Declination.

1. To lon. 7s. 29° 17′ 21″, the eclip. decl. is 20° 1′ 14″ S.

2. To decl. 20° 1′ 14″, and lat. 1°, the reduct. is 1′ 25″

					L. L.
3. As	-	60	0	lat.	0
To	-	1	25		16269
So	-	58	52		83
To	-	1	23		16352

	°	′	″	
4. From the given latitude		58	52	N.
Subtract the reduct.		— 1	23	
Diminished latitude - -		57	29	N.
From the ecliptic declination	20	1	14	S.
Subtract the diminished latitude		— 57	29	N.
Declination of Mars -	19	3	45	S.

The right ascension of Mars in time = 15h. 49m. 11s. and declination south = 19° 3′ 45″.

6. Required the right ascension and declination of the planet Mars, when his geocentric longitude is 7s. 0° 19′ 19″, and latitude 51′ 41″ north?

For

For the Right Aſcenſion.

		S.	°	′	″
1. To longitude	- -	7	0	19	19
The reduction is	- -		— 2	6	30
Ecliptic right aſcenſion	-	6	28	12	49
Correction	- -		+ 18	27	
Right aſcenſion	- -	6	28	31	16
Or	- - -		208	31	16
In time	- - -		13h.	54m.	5s.

For correcting the Ecliptic Right Aſcenſion.

2. To long. 7s. 0° 19′ 19″, and lat. 1°, the reduct. is 21′ 26″.

		′	″		L. L.
3. As	-	60	0	Lat.	0
To	-	21	26		4471
So	-	51	41	Lat.	648
To	-	18	27		5119

For the Declination.

1. To long. 7s. 0° 19′ 19″, the eclip. declin. is 11° 36′ 10″ S.

2. To declin. 11° 36′ 10″, and lat. 1°, the reduct. is 3′ 48″.

		′	″		L. L.
3. As	-	60	0	Lat.	0
To	-	3	48		11984
So	-	51	41	Lat.	648
To	-	— 3	16		12632
Diminiſhed lat.		48	25		

		°	′	″	
4. From the ecliptic declination	-	11	36	10	S.
Subtract the diminiſhed latitude	-	— 48	25		N.
Mars's declination	- -	10	47	45	S.

The right aſcenſion of Mars in time 13h. 54m. 5s. and declination 10° 47′ 45″ ſouth.

7. It

7. It is required to calculate the right ascension and declination of the planet Jupiter, his geocentric longitude being 0s. 18° 36′ 50″, and latitude 1° 21′ 5″ south?

For the Right Ascension.

		S. ° ′ ″
1. To longitude	-	0 18 36 50
The reduction is	-	— 1 26 54
Ecliptic right ascension	-	0 17 9 56
Correction	- - -	+ 31 1
Right ascension	-	0 17 40 57
Or in time	- -	1 h. 10 m. 43 s.

For the correction of Right Ascension.

		°	′	″
2. To long. 0 18 36 50 and lat. 2, the reduction is			45	52
——————————lat. 1 ——————			22	59
Difference	-		22	53

		′	″		L. L.
3. As	-	60	0	Lat.	0
To	-	22	53		4186
So	-	21	5	Lat.	4542
To	-	8	2		8728
Add	-	22	59		
		31	1	= the correction	

For the Declination.

To long. 0s. 18° 36′ 50″, the eclip. declin. is 7° 18′ 7″ N.

	′	″
2. To declin. 7° 18′ 7″, and lat. 2°, the reduct. is	9	0
——————————lat. 1 ——————	4	30
Difference - -	4	30

3. As

		′	″		L. L.
3. As	-	60	0	Lat.	0
To	-	4	30		11249
So	-	21	5	Lat.	4542
To	-	1	34		15791
Add	-	4	30		
		6	4		

	°	′	″	
4. From the given latitude -	1	21	5	S.
Subtract - - -		— 6	4	
Diminiſhed latitude - -	1	15	1	S.

	°	′	″	
5. From the ecliptic declination -	7	18	7	N.
Subtract the diminiſhed latitude -	— 1	15	1	S.
Jupiter's declination - -	6	3	6	N.

Jupiter's right aſcenſion in time 1h. 10m. 43s. and declination 6° 3′ 6″ north.

8. Required the right aſcenſion and declination of the planet Jupiter, when his geocentric longitude is 1s. 18° 20′ 34″, and latitude 1° 11′ 33″ ſouth?

For the Right Aſcenſion.

	S.	°	′	″
1. To longitude - -	1	18	20	34
The reduction is - -		— 2	28	3
Ecliptic right aſcenſion -	1	15	52	31
Correction - -		+ 20	38	
Right aſcenſion -	1	16	13	9
Or - - -		46	13	9
In time - -		3h.	4m.	52s.

For

For the correction of Right Aſcenſion.

2. To long. 1s. 18° 20′ 34″, and lat. 2°, the reduct. is 34′ 30″
——————————lat. 1——————— 17 20
Difference - 17 10

				L. L.
3. As	-	60′ 0″	Lat.	0
To	-	17 10		5435
So	-	11 33	Lat.	7156
To	-	3 18		12591
Add	-	17 20		
		20 38	= correction	

For the Declination.

1. To long. 1s. 18° 20′ 34″, the ecliptic declin. is 17° 18′ 29″ N.

2. To declin. 17° 18′ 29″, and lat. 2°, the reduct. is 4′ 39″
——————————lat. 1——————— 2 22
Difference - 2 17

				L. L
3. As	-	60′ 0″	Lat.	0
To	-	2 17		14196
So	-	11 33	Lat.	7156
To	-	0 26		21352
Add	-	2 22		
Reduction		2 48		

4. From the given latitude	-	1 11 33	S.
Subtract the reduction	-	— 2 48	
Diminiſhed latitude	- -	1 8 45	S.

5. From the ecliptic declination	-	17 18 29	N.
Subtract diminiſhed latitude	-	— 1 8 45	S.
Jupiter's declination	-	16 9 44	N.

Jupiter's

Jupiter's right aſcenſion in time 3h. 4m. 52s. and declination 16° 9′ 44″ north.

9. It is required to calculate the right aſcenſion and declination of the planet Saturn, when his geocentric longitude is 2s. 22° 20′ 43″, and latitude 58′ 11″ ſouth?

For the Right Aſcenſion.

	S.	°	′	″
1. To longitude	2	22	20	43
The reduction is		—	40	53
Ecliptic R. A.	2	21	39	50
Correction		+	3	38
R. Aſcenſion	2	21	43	28
Or		81	43	28
In time	5h.	26m.	53s.	

For the Correction of R. A.

2. To long. 2s. 22° 20′ 43″, and lat. 1°, the reduct. is 3′ 45″.

	′	″		L. L.
3. As	60	0	lat.	0
To	3	45		12041
So	58	11	lat.	134
To	3	38	correct.	12175

For the Declination.

1. To lon. 2s. 22° 20′ 43″, the eclipt. decl. is 23° 14′ 18″ N.

2. To declin. 23° 14′ 18″, and lat. 1°, the reduct. is 10″.

	′	″		L. L.
3. As	60	0	lat.	0
To	0	10		25563
So	58	11	lat.	134
To	0	9		25697

	′	″
4. From the given lat.	58	11
Subtract the reduct.	—	9
Diminiſhed lat.	58	2

	°	′	″	
5. From the ecliptic declinat.	23	14	18	N.
Subtract the diminiſhed lat.	—	58	2	S.
Saturn's declination	22	16	16	N.

Saturn's right aſcenſion in time 5h. 26m. 53s. and his declination 22° 16′ 16″ N.

Of the Cycles of the Planets, or their returns to the ſame poſition with reſpect to the Sun and Earth.

THE time when any planet, ſeen from the earth, leaves any particular poſition, ſuch as a conjunction with the ſun until its return to the ſame again, on the ſame day and hour, depends on the proper motion of the planet and of the earth round the ſun in their orbits. This time is called the *ſynodical revolution* of the planet, and by ſome its cycle. Every planet has a cycle peculiar to itſelf.

The cycle of Mercury is 79 years, for in that time the planet makes 328 revolutions round the ſun, and 1° 26′ more; and the earth falls ſhort of 79 revolutions by 7′ 43″; and therefore they are very near the ſame poſition as at the beginning of the cycle, according to their mean motions. All the different poſitions of Mercury and the Sun, ſuch as their conjunctions, the times of the planet's greateſt elongation, riſing, ſetting, and coming to the meridian of any place, occur during the time of a cycle; and all theſe poſitions happen in the ſame order, on the ſame days of the month, and nearly at the ſame hours of the day, during the next cycle. But it muſt be remembered, that the mean motions of which we ſpeak differ from the true more or leſs according to their anomalies.

The cycle of Venus is 8 years, for in that period Venus makes 13 revolutions round the ſun and 1° 32′ 14″ more; and the earth makes 8 revolutions and 3′ 41″ more, according to mean motions. Venus paſſes through all her different poſi-

poſitions with reſpect to the ſun, and appearances with reſpect to any place of the earth during her cycle; ſuch as her conjunctions with the ſun, her greateſt elongations, her times of being the morning and evening ſtar; as alſo the times of her riſing, ſetting, and being on the meridian of any place; and if theſe be known for every day of one cycle, they are known nearly during the next cycle.

The cycle of Mars is 79 years; for in that time he moves round the ſun 42 times and 1° 33′ 8″ more; and the earth falls ſhort of 79 revolutions about 8′ 1″ by mean motions. Therefore, in whatever poſition the Sun and Mars are at any given time, after 79 years, they will be nearly in the ſame; and every appearance of the planet to a ſpectator in any place of the earth during the cycle, will return nearly at the ſame times in the next cycle.

Jupiter's cycle is 83 years; wherein he moves 7 times round the ſun, and 3′ 37″ more; and the earth goes round the ſun 83 times, wanting 5′ 52″; and therefore their places differ only 9′ 29″ at the end of the cycle, by reckoning their mean motions, which is ſufficiently exact. Some make Jupiter's cycle only 12 years and 5 days; wherein Jupiter makes one revolution round the ſun, and 4° 46′ 14″ more; and the earth exceeds 12 revolutions by 5° 1′ 16″; ſo that their mean motions differ only 15′ at the end of the cycle: wherefore, if Jupiter's poſitions, with reſpect to the ſun, be calculated for 12 years 5 days, they will be nearly the ſame during the following period of 12 years, &c.

The cycle of Saturn is 59 years 2 days; for in this ſpace of time he goes twice round the ſun, and 1° 55′ 22″ more; and the earth goes 59 times round the ſun, and 1° 41′ 17″ more; ſo that their mean motions differ only 14′ at the end of the cycle, which, being ſmall, may be neglected. Therefore, if Saturn's mean longitude, latitude, anomaly, and diſtance, from the ſun be calculated, or otherwiſe known for any time as ſeen from a given place on earth, all theſe will be nearly

nearly the ſame at the end of 59 years 2 days. And the ſame is true of all the other planets with reſpect to their proper cycles.

PROB. XXIV. *To calculate what time a Planet will be on the Meridian any given day.*

CALCULATE the right aſcenſions of the ſun and planet in time for the noon of the given day, and ſubtract the ſun's right aſcenſion from that of the planet; the remainder will be the time when the planet is on the meridian, nearly.

If greater accuracy is required, calculate the right aſcenſions of the ſun and planet again for the time already found, and ſubtract as before; the remainder will be the true time when the planet will be on the meridian.

Note. When the planet's right aſcenſion is leſs than the ſun's, add 24 hours to it, and ſubtract the ſun's right aſcenſion from the ſum.

EXAM. It is required to find the time when the planet Mercury was on the meridian of London 31ſt Jan. 1796?

	H.	m.	s.
At that time Mercury's right aſcenſion -	21	41	0
And the ſun's right aſcenſion - -	20	55	38
Anſwer - - - -	0	45	22

That is, Mercury was on the meridian 45 minutes after the ſun. Here the ſecond part of the rule is uſeleſs; for the right aſcenſion of Mercury cannot vary above half a minute in three quarters of an hour; and the ſun's not above 12 ſeconds.

Note 1. The rule directs to find the right aſcenſions for the noon of the given day, which is the moſt proper time, when the calculation muſt begin with finding the longitudes, and from

from thence the right aſcenſions of the ſun and planet; but if theſe be found for any time nearer to the moment when the planet is on the meridian than noon, the anſwer will be more accurate.

2. When one wiſhes to know the time when any planet will be on the meridian, it is a good method to calculate the longitude of the ſun, and the geocentric longitude of the planet, for the noon or midnight of the given day; and by ſubtracting the ſun's longitude from the planet's, the remainder, turned into time, will be nearly the anſwer. Then calculate the right aſcenſions accurately for this time, and by ſubtracting the ſun's right aſcenſion from the planet's, the time when the planet is on the meridian will be truly found.

EXAM. 1. It is required to calculate the time when the planet Mercury will be on the meridian of the Iſland Bermuda, in longitude 63° 32′ W. January 15th 1798?

Anſwer, at 1h. 13m. 14s.

	D.	h.	m.	s.
January - . -	15	0	0	0
Equation of time - -		+	10	3
Difference of meridians weſt -		+	4	14	8
Mean time at Greenwich when it is noon at Bermuda.	15	4	24	11

	S.	°	′	″
At this time Mercury's geocent. long.	10	13	55	29
Sun's longitude - -	— 9	25	53	19
Difference -	0	18	2	10

which in time is 1h. 12m. 8s. when the planet is on or very near the meridian of Bermuda.

1798, Jan. 15 d. 1 h. 12 m. 8s. the ſun's longitude = 9s. 25° 45′ 0″, R. aſcenſion 19h. 50m. 54s.

Mercury's geocentric long. 10s. 13° 41′ 31″, and lat. 25′ 46″ N.

For

For Mercury's R. Aſcenſion.

	S. ° ′ ″
To longitude -	10 13 41 31
The reduction is - -	+ 2 18 24
Ecliptic right aſcenſion -	10 16 9 55
Correction - - -	— 7 41
Right aſcenſion -	10 16 2 14
Or - - -	316 2 14

	h. m. s.
In time - -	21 4 8
Sun's R. A. - -	— 19 50 54
Mercury on the meridian -	1 13 14

For the Correction.

To long. 10s. 13° 41′ 31″, and lat. 1°, the correct. is 17′ 55″.

	′ ″	L. L.
As -	60 0 Lat.	0
To -	17 55	5249
So -	25 46 Lat.	3671
To -	7 41	8920

2. It is required to find the time when the planet Venus will be on the meridian of Glaſgow 1797, Octob. 20th?

Compute the longitudes and R. aſcenſions for 2h. 30m. P. M. *Anſ.* 2h. 27 m. 5s.

	D. h. m. s.
Octob. - -	20 2 30 0
Diff. merid. W. -	+ 16 20
Equation of time - -	— 15 13
Mean time at Greenwich	20 2 31 7

At this time the ſun's long. is 6s. 27° 42′ 0″, R. A. 13h. 42m. 13s. and log. of the earth's diſt. 4.997591.

The

The heliocentric long. of Venus 10 s. 0° 27′ 21″, and lat. 2° 25′ 21″ S.

The geocentric long. 8 s. 4° 50′ 44″, and latitude 1° 27′ 54″ S.

	h.	m.	s.
The R. aſcenſion of Venus in time	16	9	56
Sun's R. aſcenſion - - —	13	42	51
Venus is on the merid. of Glaſgow at	2	27	5

3. It is required to find the time when the planet Mars will be on the meridian of Greenwich 1797, Dec. 1ſt? *Anſ.* 21 h. 19m.

	h.	m.	s.
Dec. 1ſt, at noon, the R. A. of Mars is	13	54	5
R. A. of the ſun - - —	16	32	51
Mars on the merid. at - -	21	21	14

If the R. aſcenſion of the ſun and planet be recomputed for 21 h. 14m. afternoon of the 1ſt, or in civil time for 9 h. 14 m. in the morning of the 2d Dec. it will be found that

	h.	m.	s.
The right aſcenſion of Mars is	13	55	41
And of the ſun - - —	16	36	38
Mars on the meridian at - -	21	19	3

or 9 h. 19m. in the morning of Dec. 2d.

4. Required the time when the planet Jupiter is on the meridian of Edinburgh, 1797, July 11th?

	h.	m.	s.
Jupiter's R. A. at noon is -	1	10	45
Sun's R. A. - - —	7	25	3
Jupiter on the merid. -	17	45	42

By computing the longitudes and R. aſcenſions for July 11d. 17 h. 45 m. 42 s.

Jupiter's

	h.	m.	s.
Jupiter's R. A. is - -	1	10	55
And the ſun's R. A. -	— 7	27	34
Jupiter is on the merid. at -	17	43	21

5. What time will the planet Saturn be on the meridian of Greenwich, 1797, April 1ſt?

	h.	m.	s.
On the given day Saturn's R. A. at noon is	5	26	53
And the ſun's R. A. - -	— 0	45	2
Saturn is nearly on the meridian at -	4	41	51

CHAP. VI.

Of the Time when the Moon is on the Meridian; and of the Riſing and Setting of the Sun, Moon, and other Planets.

PROB. XXV. *To find the Time when the Moon is on the Meridian of a given place any given Day.*

1. CALCULATE the longitude and latitude of the moon, as alſo the longitude of the ſun and their right aſcenſion for noon, or any other hour of the given day, in the meridian of the given place; and ſubtract the ſun's right aſcenſion from the moon's, both being expreſſed in time: the remainder is nearly the time when the moon is on the meridian.

2. Cal-

2. Calculate the right aſcenſions of ſun and moon again for this time, and then ſubtract as before; the remainder is the true time when the moon is on the meridian.

Note: If great preciſion is required, calculate the right aſcenſions again for the time now found, and ſubtract as before.

EXAM. 1. It is required to find what time the moon was on the meridian of Greenwich, June 22d 1795? *Anſ.* at 5h. 1m. 9s.

At apparent noon that day the moon's longitude was 5s. 11° 18′ 41″, and her latitude 3° 29′ 9″ N. Sun's long. 3s. 0° 55′ 29″, and R. A. 6h. 4m. 2s.

For the Moon's R. A.

	s.	°	′	″
To longitude - -	5	11	18	41
The reduct. is -	+ 1	27	3	
	5	12	45	44
Correction - -	+ 1	20	56	
Moon's R. A. - -	5	14	6	40
Or - - -	164	6	40	
In time - -	10h.	56m.	26s.	

	h.	m.	s.
From the moon's R. A. -	10	56	26
Subtract the ſun's -	6	4	2
Eſtimate time of ☽'s being on mer.	4	52	24

For the correction of Moon's Right Aſcenſion.

	°	′	″
Long. 5s. 11° 18′ 41″ and lat. 4° gives	1	32	56
—— —— —— —— lat. 3° ——	1	9	31
Difference - -	0	23	25

Z As

		′	″		L. L.
As	-	60	0	Lat.	0
To	-	23	25		4086
So	-	29	9	Lat.	3135
To	-	11	22		7221
Add	-	1°	9	34	
		1	20	56	= correction.

Now, by calculating the moon's R. A. the 23d at noon, and ſubtracting that of the 22d from it, we find the daily difference to be 47m. 24s.; and then as 24h. : 47m. 24s. : : 4h. 52m. 24s. : 9m. 35s. to be added to the moon's R. aſcenſion.

	h.	m.	s.
To moon's R. A. - -	10	56	26
Add - - -		+9	35
Moon's R. A. at eſtimate time	11	6	1
Sun's ſubtract - -	—6	4	52
Moon on the meridian at -	5	1	9

	h.	m.	s.
To Sun's R. A. - -	6	4	2
Add for 4h. 52m. -		+50	
Sun's R. A. at eſtimate time -	6	4	52

2. It is required to find when the moon is on the meridian of Edinburgh, 1796, July 7th? *Anſ.* at 2h. 35m. 31s.

By a former calculation, p. 110—117. at 7h. 29m. 30s. apparent time, in the meridian of Edinburgh, the moon's longitude was 4s. 25° 42′ 29″, and latitude 3° 44′ 21″ N. The ſun's longitude was 3s. 16° 15′ 19″, and right aſcenſion 7h. 10m. 32s.

For

For the Moon's R. A.

	s.	°	′	″
To longitude - -	4	25	42	29
The reduction is - -	+	2	15	54
	4	27	58	23
Correction - -	+	1	18	48
Moon's right aſcenſion -	4	29	17	11
Or - - -		149	17	11

	h.	m.	s.
In time - -		9	57	8
Sun's R. A. - -	—	7	10	32
Eſtimate time - -		2	46	36

For the correction of Right Aſcenſion.

	°	′	″
Long. 4s. 25° 42′ 29″ and lat. 4° gives	1	24	21
——— lat. 3° ———	1	3	8
Difference	0	21	13

		′	″		L.	L.
As	-	60	0	Lat.	0	
To	-	21	13		4515	
So	-	44	21	Lat.	1313	
To	-	15	40		5828	
Add		1°	3	8		
		1	18	48 = correction.		

In this example ſubtract the eſtimate time from the time calculated for; becauſe the moon is on the meridian before that time. Find the daily difference of the moon's R. A. and then, as 24h. is to the daily difference, ſo is the remainder to a 4th proportional; which being ſubtracted from the eſtimate time, the remainder is the anſwer.

Time

	h.	m.	s.
Time calculated for -	7	29	30
Eſtimate time - -	— 2	46	36
Remainder - -	4	42	54

The daily difference of moon's R. A. is 56m. 20s.

h.	h.	m.	s.	m.	s.	m.	s.
As 24	: 4	42	54	: : 56	26	: 11	5

	h.	m.	s.
From the eſtimate time -	2	46	36
Subtract - - -	— 11		5
Moon on the meridian at -	2	35	31

3. It is required to find the time when the moon will be on the meridian of Bengal in latitude 22° N. and longitude 92° 45′ E. 1797, Nov. 4th? *Anſ.* at 12h. 9m. or a little after midnight.

1ſt, Find the mean time at Greenwich, when it is apparent noon at Bengal, thus.

	D.	h.	m.	s.
Apparent noon at Bengal, Nov.	4	0	0	0
Equation of time - -			— 16	13
Mean time at Bengal -	3	23	43	47
Difference of meridians E. -		— 6	11	0
Mean time at Greenwich -	3	17	32	47

Sun's long. 7s. 12° 19′ 54″, mean anomaly 4s. 4° 26′ 13″, R. A. 14h. 39m. 31s.

For

For the Longitude of the Moon.

	m. Long.				m. Anom.				☊			
	S.	°	′	″	S.	°	′	″	S.	°	′	″
1797 -	10	7	34	43	0	24	6	53	3	1	15	6
Nov. 3d -	2	25	9	14	1	20	57	5				
17h. -			9	20	0		9	15	16	— 16	15	26
32m. - -				17	34			17	25		— 2	15
47s. - -					26				25			— 4
	1	12	21	57	2	24	37	4	2	14	57	21
10 equations		+ 1	33	11			+ 18	4			+ 7	40
	1	13	55	8	2	24	55	8	2	15	5	1
Centre -		— 6	15	16			+ 1	33	11			
☽'s equat. long.	1	7	39	52								
12th equation			— 5	59	2	26	28	19	= 11th arg.			
	1	7	33	53								
13th equation			—	26								
☽'s orbit long.	1	7	33	27								
Reduction -			+ 6	34								
☽'s eclipt. long.	1	7	40	1								
Equinoxes -			—	17								
Moon's long.	1	7	39	44								
Latitude S. -		3	5	0								

Arguments.

	Arguments.				Equations.			
					+			—
	S.	°	′	″	°	′	″	′ ″
1	4	4	26	13	0	9	17	
2	4	4	30	19				0 47
3	7	25	37	53	0	1	2	
4	2	24	41	10	0	0	57	
5	9	5	27	2	1	20	0	
6	1	9	53	15	0	1	19	
7	5	1	0	49	0	0	23	
8	10	20	10	51				0 27
9	3	5	24	59	0	0	33	
10	7	2	37	27	0	0	54	
								—1 14
					+1	34	25	
					—0	1	14	
					1	33	11	sum of 10 equats.
12	5	25	19	58				
13	6	18	29	25				
14	10	22	28	26				

For the Moon's Latitude.

	Arguments.						
	S.	°	′	″		° ′ ″	
1	10	22	28	52	—	3 8	58
2	0	28	11	4	+	0 4	9
3	7	27	51	48	+	0 0	14
4	5	3	14	44	—	0 0	11
5	2	8	37	40	—	0 0	14
					☽'s latitude	3 5	0 S.

For

For the Moon's Right Aſcenſion.

	S.	°	′	″
To longitude - -	1	7	39	44
The reduction is - -	—	2	21	52
	1	5	17	52
Correction - -	+	1	1	16
Moon's Right aſcenſion -	1	6	19	8
Or - - -		36	19	8

	h.	m.	s.
In time - - -	2	25	16
Sun's R. A. - -	— 14	39	31
Eſtimate time of ☽ on the meridian	11	45	45

For the Correction.

	°	′	″
Long. 1s. 7° 39′ 44″ and lat. 4° gives	1	19	15
—— —— —— —— —— lat. 3° ——	0	59	38
Difference -	0	19	37

		′	″		L. L.
As	-	60	0	Lat.	0
To	-	19	37		4855
So	-	5	0	Lat.	10792
To	-	+1	38		15647
Add	-		59	38	
		1	1	16 = correct.	

To find the time more perfectly, the daily difference of the moon's R. A. is 13°, or 52 m. of time; and

h. m. h. m. s. m. s.

As 24 : 52 : : 11 45 45 : 25 29 to be added to the moon's R. A.

At

	h.	m.	s.
At apparent noon in the merid. of Bengal the moon's R. A. is	2	25	16
Add	+	25	29
Moon's R. A. at the eſtimate time	2	50	45
Sun's R. A. at the ſame time	14	41	31
Moon on the meridian of Bengal at	12	9	14

Note. In the following Problems relating to the riſing and ſetting of the ſun, the latitudes of the places mentioned are not marked with preciſion.

PROB. XXVI. *The Latitude of the Place, and the ſun's Declination being given, to find the time of his riſing and ſetting.*

CALCULATE the ſun's declination for the eſtimate time of ſun riſing or ſetting, and then, by the latitude of the place, and the ſun's declination, find the aſcenſional difference: thus, to the logarithm tangent of the latitude add the logarithm tangent of the declination; the ſum, rejecting radius, is the ſine of the aſcenſional difference; which being reduced to time, and added to or ſubtracted from 6 hours, gives the time of ſun riſing or ſetting.

Note 1. The time of ſun riſing is called *the ſeminocturnal arch*, and the time of ſun ſetting *the ſemidiurnal.*

Note 2. When the ſun's declination and the latitude of the place are of the ſame name, that is, both north or both ſouth, the aſcenſional difference in time is to be ſubtracted from 6 hours for the time of ſun riſing, and added to 6 hours for the time of ſun ſetting. But when the declination and latitude have different names, the aſcenſional difference is to be ſubtracted from 6 hours for the time of ſetting, and added for the time of riſing.

EXAM. 1.

EXAM 1. It is required to find the time of sun rising and setting at London, or any place in latitude 51° 32′ north, on the 1st day of January 1797?

		°	′	″	
Sun's declination, January 1st	-	22	57	5	S.
—— 2d	-	22	51	30	
Daily difference	- -	0	5	35	

The estimate times of sun rising and setting is about 4 hours before and after noon.

As 24h. : 5′ 35″ : : 4h. : 56″.

At sun rising his declination = 22° 58′ 1″ south, and at setting = 22° 56′ 9″ south.

1. For the ascensional difference at sun rising.

		°	′	″		
Tangent latitude	-	51	32	0		10.0999135
Tangent declin.	-	22	58	1		9.6271549
Ascen. diff.	-	32	14	10	Sine	9.7270684
				4		
In time		2h.	8m.	56s.	40	
Add	-	6				
Sun rises		8h.	8m.	56s.		

2. For the ascensional difference at setting.

		°	′	″		
Tangent	-	51	32	0		10.0999135
Tangent	-	22	56	9		9.6264982
Ascen. difference	-	32	10	50	Sine	9.7264117
				4		
In time	—	2h.	8m.	43s.	20	
					6	
Sun sets	-	3h.	51m.	17s.		

2. It is required to find the time of ſun riſing and ſetting at Gibraltar, in lat. 36° 5′ N. and long. 4° 46′ W. Jan. 1ſt, 1797?

The difference of meridians being ſmall, the ſun's declinations at riſing and ſetting are the ſame as in laſt example.

For the time of ſun riſing.

		°	′	″	
Tangent lat.	-	36	5	0	9.8625887
Tangent declin.	-	22	58	1	9.6271549
		17	59	20	9.4897436
				4	

Aſcen. diff.	1h. 11m. 57s.	20
Add	- 6	
Sun riſes	- 7h. 11m. 57s.	

For the ſun ſetting.

		°	′	″	
Tangent lat.	-	36	5	0	6.8625887
Tangent decl.	-	22	56	9	9.6264922
		17	57	40	9.4890809
				4	

Subtract	— 1h. 11m. 50s.	40
From	- 6	
Sun ſets at	4h. 48m. 10	

Note. In calculating by this rule one operation is ſufficient; for when the time of riſing is found, ſubtract it from 12 hours, and the remainder is the time of ſetting, very nearly.

3. What time does the ſun riſe and ſet at Halifax, latitude 44° 46′ N. and longitude 63° 20′ W. April 30th, 1796?

April 30th, in latitude 44° 46′ N. the ſun riſes about 5 in the morning.

Sun

	D.	h.	m.	s.	
Sun rises at Halifax, April	29	17	0	0	by estimation
Diff. of meridians add -		+ 4	13	20	
Time at London -	29	21	13	20	

	Declin. N. °	′	″
April 30th - -	15	4	41
—— 29th - -	14	46	25
Difference - -	0	18	16

As 24 h. : 18′ 16″ : : 21 h. 13 m. 20 s. : 16′ 8″.

	°	′	″
To - - -	14	46	25
Add - - - -	+ 16	8	
When the sun rises at Halifax, declin. -	15	2	33 N.

	°	′	″	
Tangent lat. -	44	46	0	9.9964627
Tangent declin. -	15	2	33	9.4293394
Ascen. diff. -	15	27	30	9.4258021
			4	
In time -	— 1 h.	1 m.	50 s.	0
	6	0	0	0
Sun rises at -	4 h.	58 m.	10 s.	

	H.	m.	s.
From - - -	12	0	0
Subtract - -	— 4	58	10
Sun sets at - -	7	1	50

4. On the 15th February, 1797, required the time of sun rising and setting at Vienna, latitude 48° 11′ N. and longitude 16° 23′ E. ?

	°	′	″
Feb. 15th, sun's declin. at Greenwich is	12	23	37
For the difference of merid. 1 h. 5 m. 32 s. add		+	56
Declination in the meridian of Vienna -	12	24	33
For the estimate time of sun rising 6 h. 40 m. add		+ 5	44
Sun's declination at rising - -	12	30	17 S.

Tan-

	°	′	″	
Tangent lat. -	48	11	0	10.0483581
Tangent declin. -	12	30	17	9.3459246
Aſcen. diff. - -	14	21	10	9.3942827
			4	

In time	0h.	57m.	24s.	40
Add -	6	0	0	0
Sun's riſing	6h.	57m.	24s.	

	H.	m.	s.
From - - -	12	0	0
Subtract - - -	6	57	24
Sun ſetting - - -	5	2	36.

The time of ſun riſing or ſetting, found by this rule, would be true if the earth had no atmoſphere, and conſequently the rays of light came to our eyes in ſtraight lines; but the rays of light, on entering our atmoſphere, are turned out of their proper courſe, and bent into curve lines, which is called *refraction*: and hence it is that the ſun, moon, or any ſtar, does not appear in its true place, but in the direction of a tangent to the curved ray, at the point where it enters the eye, making the ſun or ſtar appear higher in the heavens than it is. The difference between the true and apparent place is greateſt near the horizon, and decreaſes towards the zenith, where it is nothing. The centre of the ſun, or of any ſtar, appears in the horizon when it is about 33′ below it; and therefore the apparent times of the riſing or ſetting of the ſun or any ſtar will always differ ſome minutes from thoſe found by the above rule.

The following Table contains theſe differences, whereby the apparent time of the riſing or ſetting of the ſun or of any ſtar may be found whoſe declination does not exceed 30°, and for any place between the equator and 60° of latitude.

Time

Time answering to a change of 33′ of Altitude at the Horizon.

Declination.

Lat.	0°	3°	6°	9°	12°	15°	18°	21°	24°	27°	30°
°	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.
0	2 12	2 12	2 12	2 13	2 15	2 16	2 17	2 20	2 24	2 27	2 32
10	2 14	2 14	2 14	2 15	2 17	2 18	2 21	2 24	2 27	2 31	2 35
20	2 20	2 20	2 20	2 21	2 24	2 26	2 28	2 31	2 37	2 40	2 46
30	2 32	2 32	2 34	2 35	2 36	2 39	2 43	2 47	2 52	2 58	3 6
36	2 43	2 43	2 45	2 46	2 49	2 51	2 56	3 2	3 8	3 16	3 27
40	2 52	2 52	2 53	2 56	2 59	3 2	3 8	3 15	3 23	3 54	3 47
44	3 3	3 4	3 5	3 8	3 11	3 16	3 23	3 32	3 42	3 56	4 15
46	3 9	3 10	3 12	3 14	3 18	3 24	3 32	3 42	3 54	4 11	4 33
48	3 17	3 18	3 20	3 24	3 26	3 33	3 42	3 54	4 9	4 28	4 57
50	3 23	3 26	3 29	3 31	3 36	3 44	3 55	4 9	4 27	4 49	5 21
52	3 35	3 36	3 38	3 42	3 48	3 58	4 9	4 26	4 47	5 17	6 7
54	3 44	3 46	3 49	3 53	4 0	4 10	4 24	4 44	5 10	5 53	7 7
56	3 55	3 57	4 0	4 6	4 14	4 26	4 31	5 16	5 39	6 44	8 46
57	4 1	4 3	4 7	4 13	4 22	4 35	4 56	5 21	6 1	7 18	
58	4 8	4 10	4 14	4 20	4 31	4 45	5 8	5 41	6 28	8 2	
59	4 15	4 17	4 22	4 29	4 40	4 56	5 20	6 0	6 58		
60	4 24	4 26	4 31	4 38	4 50	5 8	5 35	6 22	7 33		

PROB. XXVII. *The Latitude of the place, and the Sun's Declination, being given, to find the Apparent Time of Sun rising or setting by the help of the Table.*

BY the given latitude and declination calculate the aſcenſional difference and time of riſing or ſetting by the laſt Problem, which may be called the *approximate time*. Then enter the table with the latitude on the ſide, and the declination on the head (making proportion for the odd parts not found in the table), and take out the equation, which is to be ſubtracted from the approximate time of riſing, and added to it at ſetting; the reſult is the apparent time required.

EXAM. 1. It is required to find the apparent time of ſun riſing and ſetting at London, latitude 51° 32′ N. June 1ſt 1796? *Anſ.* ſun riſes at 3h. 51m. 43s. and ſets at 8h. 8m. 8s.

At 4h. in the morning ſun's declination is 22° 9′ 19″ N.

		°	′	″	
Tan. latitude		51	32	0	10.0999135
Tan. declination		22	9	19	9.6097888
Aſcenſional diff.		30	55	50	Sin. 9.7097023
				4	
		h.	m.	s.	
In time	—	2	3	43	20
		6			
Approx. time		3	56	17	
Equation			— 4	34	
App. time of riſing		3	51	43	

At

At 8h. in the evening the sun's declination is 22° 14′ 23″.

	° ′ ″	
Tan. latitude	51 32 0	10.0999135
Tan. declination	22 14 23	9.6116186
Ascen. diff. -	30 58 30	Sin. 9.7115321
	4	

	h. m. s.
In time -	2 3 54 0
Add -	6
	8 3 54
Equation -	+ 4 34
Appar. time of sett.	8 8 28

2. Required the apparent time of sun-rising and setting at Glasgow; lat. 55° 5′ N. and long. 4° 5′ W. Oct. 12th 1796?

	° ′ ″
Sun's decl. at noon in the merid. of Glasgow	7 46 46 S.
At sun-rising - - -	7 41 10
At sun-setting - - -	7 52 19

For the apparent time of Sun-rising.

	° ′ ″	
Tan. latitude	55 5 0	10.1561183
Tan. declination	7 41 10	9.1302002
Ascen. diff. -	11 8 50	Sin. 9.2863185
	4	

	h. m. s.
In time -	0 44 35 20
Add -	6 0 0
Approx. time	6 44 35
Equation -	— 3 56
App. time of rising	6 40 39

For

For the apparent of Sun-setting.

		° ′ ″	
Tan. latitude		55 5 0	10.1561183
Tan. declination		7 52 19	9.1407196
Ascen. diff.	-	11 25 20	Sin. 9.2968379
		4	

		h. m. s.
In time	-	— 0 45 41 20
		6 0 0
Approx. time		5 14 19
Equation	-	+ 3 56
App. time of sett.		5 18 15

3. Required the apparent time of sun-rising and setting at Edinburgh, lat. 56° N. and long. 3° W. July 7th 1797?

	° ′ ″
On the given day at noon sun's declin.	22 32 21 N.
At sun-rising - -	22 34 35
At sun-setting - -	22 30 7

For Sun-rising.

		° ′ ″	
Tan. latitude		56 0 0	10.1710126
Tan. declination		22 34 35	9.6188598
Ascen. diff.	-	38 3 17	Sin. 9.7898724
		4	

		h. m. s.
Subtract	—	2 32 13 8
From	-	6 0 0
Approx. time		3 27 47
Equation	-	— 5 27
Apparent rising		3 22 20

For

For Sun-ſetting.

		°	′	″	
Tan. latitude		56	0	0	10.1710126
Tan. declination		22	30	7	9.6172660
Aſcen. diff.	-	37	53	20	Sin. 9.7882786
				4	

	h.	m.	s.	
	2	31	33	20
	+ 6	0	0	
	8	31	33	
Equation -	+	5	27	
Apparent ſetting	8	37	0	

PROB. XXVIII. *The Latitude of the Place, with the Right Aſcenſion and Declination of a Fixed Star, being given, to find the Apparent Time of its Riſing and Setting, any given Day.*

CALCULATE the time when the ſtar is on the meridian by Prob. III. p. 45.: then find its ſemidiurnal arch thus; calculate its aſcenſional difference by the laſt problem, and reduce it to time; then if the ſtar's declination be of the ſame name with the latitude of the place, add the aſcenſional difference in time to 6 hours; but if it is of a contrary name, ſubtract it from 6 hours, and the ſum or remainder will be the ſemidiurnal arch of the ſtar in time.

Subtract the ſemidiurnal arch from the time when the ſtar is on the meridian, the remainder is the time of the ſtar's riſing; and add the ſame two numbers for the time of its ſetting.

EXAM. 1. January 20th 1796, what time does the ſtar Aldebaran riſe and ſet at Edinburgh, latitude 56° N.? *Anſ.* Riſes 0h. 27m. 13s. Sets 15h. 58m. 35s.

	h.	m.	s.
Aldebaran's R. A. - -	4	24	13
Sun's ditto at noon - -	20	9	52
	8	14	21
Equation for 8h. - -	—	1	27
Aldebaran on the meridian at - -	8	12	54 apparent time.

For Aldebaran's ſemidiurnal arch; his declination being 16° 5′ 12″ N.

	°	′	″	
Tan. latitude	56	0	0	10.1710126
Tan. declination	16	5	12	9.4599698
Aſcen. diff. -	25	18	40	Sin. 9.6309824
			4	

	h.	m.	s.	
In time -	1	41	14	40
Add -	6			
Semidiurnal arch	7	41	14	

	h.	m.	s.
Aldebaran on the meridian at -	8	12	54
Semidiurnal arch - -	+	7	41 14
Aldebaran riſes at - -	0	31	40
And ſets at - - -	15	54	8

	Riſing.			Setting.		
	h.	m.	s.	h.	m.	s.
	0	31	40	15	54	8
Equation -	—	4	27	+	4	27
Apparent time	0	27	13	15	58	35

2. No-

2. November 30th 1796, What time does the ſtar Sirius riſe and ſet at Gibraltar, latitude 36° 5′ N. and longitude 4° 46′ W.?

	h.	m.	s.
Star's R. A. - -	6	36	12
Sun's at noon - - —	16	29	34
	14	6	38
For 14 hours ſubtract -	—	2	34
Sirius on the meridian - -	14	4	4
Semidiurnal arch - ±	5	13	12
Sirius riſes at - -	8	50	52
And ſets at - -	19	17	16

For the Star's ſemidiurnal arch, his declination being 15° 26′ 44″ S.

	°	′	″		
Tan. latitude -	36	5	0		9.8625887
Tan. declination	16	26	44		9.4700872
Aſcen. diff. -	12	25	20	Sin.	9.3326759
			4		

	h.	m.	s.	
Subtract -	— 0	49	41	20
From -	6	0	0	
	5	10	19	
Equation -	+ 2	53		
Semidiurnal arch	5	13	12	

3. January

3. January 30th 1797, what time does the ſtar Regulus riſe and ſet at Bengal, latitude 22° N. and longitude 92° 45′ E.?

	h.	m.	s.
Star's R. A. - -	9	57	32
Jan. 30th Sun's R. A. - —	20	54	39
	13	2	53
For 13 hours ſubtract - -	—	2	12
Star on the merid. of Greenwich	13	0	41
For 6h. 11m. E. long. add -	+	1	5
Star on the merid. of Bengal -	13	1	46
Semidiurnal arch - - ∓	6	23	45
Regulus riſes at - -	6	38	1
And ſets at - -	19	25	31

Star's declination 12° 57′ 13″ N.

	°	′	″	
Tan. latitude -	22	0	0	9.6064096
Tan. declination -	12	57	13	9.3617572
Aſcen. diff. -	5	19	50	Sin. 8.9681668
			4	

	h.	m.	s.
In time -	0	21	19 20
Add -	6	0	0
	6	21	19
Equation -	+	2	26
Semidiurnal arch	6	23	45

4. Required

4. Required the apparent time of the rising and setting of the bright star in Pleiades at Port Royal, Jamaica, lat. 18° N. and long. 76° 45′ W. Feb. 20th 1797?

	h.	m.	s.
Star's R. A.	3	35	26
Sun's R. A. —	22	17	36
	5	17	50
For 5h. 18m. subtract —			50
Star on the merid. of Greenwich	5	17	0
For 5h. W. long. subtract —			48
Star on the merid. of Port Royal	5	16	12

	°	′	″		
Tan. latitude	18	0	0		9.5117760
Tan. declination	23	28	0		9.6376106
Ascen. diff.	8	6	30	Sin.	9.1493866
			4		

	h.	m.	s.	
In time	0	32	26	0
Add	6	0	0	
	6	32	26	
Equation +		2	31	
Semidiurnal arch	6	34	57	

	h.	m.	s.
Star on meridian	5	16	12
Semidiurnal arch +	6	34	57
Star rises at	22	41	15
And sets at	11	51	9

PROB.

PROB. XXIX. *The Latitude of the Place, with the Moon's Longitude and Latitude at the Noon of any Day, being given, to find the Apparent Time of her Riſing or Setting.*

CALCULATE the right aſcenſion of the ſun in time, and alſo of the moon, for the noon of the given day. Subtract the ſun's right aſcenſion from the moon's, the remainder is the eſtimate time of the moon's being on the meridian; from which find the true time thus: Calculate the ſun and moon's right aſcenſions for the eſtimate time; and by ſubtracting the ſun's R. A. from the moon's, the remainder will be the true time of the moon's being on the meridian.

Find the moon's declination for this time; and by the latitude of the place and the moon's declination find her ſemidiurnal arch; which, being added to the time ſhe is on the meridian, the ſum is the eſtimate time of her ſetting; and being ſubtracted, the remainder is the eſtimate time of her riſing.

Laſtly, Find the moon's declination at the eſtimate time of her riſing or ſetting, and calculate her ſemidiurnal arch again; which being ſubtracted from or added to the true time of her being on the meridian, the apparent time of the moon's riſing or ſetting will be known.

Note: Between the conjunction and oppoſition, or from change to full, the moon's ſetting is required, and from the full to the change it is the moon's riſing.

EXAM. 1. It is required to find the apparent time of moon's ſetting at Edinburgh, latitude 56° N. and longitude 3° 6′ 15″ W. July 7th 1796?

	m.	s.
Difference of meridians -	+ 12	25
Equation of time - -	+ 4	33
	16	58

The mean time of noon in the meridian of Greenwich is July 7d. oh. 16m. 58s.

Sun's

Sun's long. 3 s. 15° 57′ 17″. R. A. in time 7 h. 9 m. 15 s.
Moon's long. 4 s. 21° 14′ 57″, and lat. 3° 26′ 14″ N.

Find the Moon's Right Aſcenſion and Declination.

1. For the ☽'s R. A. at noon.

	s.	°	′	″
To longitude	4	21	14	57
The reduction is	+ 2	23	26	
	4	23	38	23
Correction	+ 1	9	26	
Moon's R. A.	4	24	47	49
Or		144	47	49
				4

	h.	m.	s.
Moon's R. A. in time	9	39	11	16
Sun's R. A. —	7	9	15	
Eſtimate time of ☽ on merid.	2	29	56	

For the Correction of R. A.

	°	′	″
Long. 4 s. 21°, &c. and lat. 4° gives	1	20	59
—— —— —— —— —— lat. 3° ——	1	0	23
Difference -	0	20	36

	′	′	″		′	″
As 60 :	20	36	: :	26	14	: 9 3
Add - -				1°	0	23
Correction -			+	1	9	26

2. For the moon's Declination at Noon.

To long. 4 s. 21° 14′ 57″ the ecliptic decl. is 14° 26′ 0″ N.

	′	″
Ecliptic declin. 14° 26′ and lat. 4° gives	12	56
—— —— —— —— —— lat. 3° ——	9	39
Difference -	3	17

As

	′	′ ″		′ ″	′	″
As 60 : 3	17	: : 26	14	: 1	26	
Add - -				9	39	
Correction -				11	5	

	°	′	″	
From moon's latitude -	3	26	14	N.
Subtract - - -	—	11	5	
Diminiſhed latitude - -	3	15	9	N.
Ecliptic declination - -	+ 14	26	0	N.
Moon's declination at noon -	17	41	9	N.

3. The eſtimate time of the moon's coming to the meridian is 2h. 30m. which gives 22″ to be added to the ſun's R. A. at noon.

The difference of the moon's R. A. in 12 hours is 28m. 40s. and as 12h. : 28m. 40s. : : 2h. 30m. : 5m. 58s. to be added to the moon's R. A. at noon.

	h.	m.	s.
Moon's R. A. at noon -	9	39	11
Add - - -	+	5	58
Ditto when on the meridian -	9	45	9
Sun's R. A. - -	—	7	9 37
Moon on the meridian -	2	35	32

4. To lat. 56° N. and declin. 17° 41′ N. the moon's ſemidiurnal arch is about 7h. 48m. which being added to 2h. 29m. the eſtimate time of the moon's coming to the meridian, the ſum 10h. 17m. is the time of the moon's ſetting nearly. Find the moon's declination at this time.

Difference of moon's declination in 12h. is 1° 58′ decreaſing. As 12h. : 1° 58′ : : 10h. 17m. : 1° 41′ to be ſubtracted from the moon's declination at noon.

From

	° ′	
From - - -	17 41	
Subtract - - -	— 1 41	
Moon's declination at ſetting -	16 0	N.

5. For the Moon's Semidiurnal Arch.

	°	′	″	
Tan. latitude - -	56	0	0	10.1710126
Tan. declination -	16	0	0	9.4579730
Aſcenſ. diff. -	25	11	15	Sin. 9.6289856
			4	

	h.	m.	s.
In time -	1	40	45
Add - -	6	0	0
Semidiurnal arch	7	40	45

	h.	m.	s.
6. Moon on the meridian at -	2	35	32
Semidiurnal arch add -	+ 7	40	45
The moon ſets at - -	10	16	17

According to this calculation the moon ſets at 10 hours 16 mimutes: but the moon's riſing and ſetting is affected by her horizontal parallax, which ſhortens her ſemidiurnal arch. The time of the moon's ſetting or riſing may be corrected thus:

Find the moon's horizontal parallax at the time, and ſubtract the horizontal refraction 33′ from it; the remainder is the depreſſion of the moon below the horizon at the time ſhe ſhould be at it if ſhe had no parallax, and therefore this remainder muſt be taken away from her ſemidiurnal arch, in order to find the time of her riſing or ſetting.

With the latitude of the place, and the moon's declination, take the equation out of the Table, p. 181. and then,

As the horizontal refraction 33′
Is to the equation;
So is the depreſſion
To the correction, to be ſubtracted from the moon's ſemi-

diurnal arch before it be applied to the time when the moon was on the meridian.

In this Example, at 10h. 12m. the moon's horizontal parallax

				′	″
Is	-	-	-	59	27
Subtract	-	-		33	0
Moon's depreſſion	-	-	-	26	27

			L.	L.
As	-	33′		2596
To	-	4m. 26s.		11654
So is	-	26′ 27″		2357
To	-	3m. 17s.		15211
				12615

				h.	m.	s.
Semidiurnal arch	-	-	-	7	40	45
Correction ſubtract	-	-			— 3	17
Correct ſemidiurnal arch			-	7	37	28
Add	-	-	-	2	35	32
The moon ſets at	-	-		10	13	0

2. It is required to find the time of the moon's ſetting at London, latitude 51° 32′ N. October 1ſt, 1797? *Anſ.* 13h. 35m.

At noon the ſun's longitude is 6s. 8° 45′ 18″, right aſcenſion 12h. 32m. 10s.

The moon's longitude 10s. 18° 1′ 32″, latitude 4° 27′ 27″ ſouth, declin. 19° 41′ S. and

				h.	m.	s.
R. aſcenſion	-	-	-	21	27	40
Sun's ditto	-	-		12	32	10
Eſtimate moon on meridian			-	8	55	30

1. At

	h.	m.	s.
1. At eſtimate time moon's R. A. -	21	45	43
Sun's - - -	12	33	31
Moon on meridian - - -	9	12	12

By renewing the operation the moon is on the meridian at 9h. 12m. 36s.

Moon's declination when on the meridian is 18° 23′ ſouth, and her ſemidiurnal arch is 4h. 21m. 6s.

	h.	m.	s.
2. Moon on the meridian at -	9	12	36
Semidiurnal arch - -	+4	21	6
Time of moon's ſetting nearly - -	13	33	42

	°	′	
3. Moon's declin. at midnight -	17	57	S. decreaſing
For 1h. 34m. ſubtract -		— 15	
Moon's declin. at ſetting -	17	42	S.

	°	′		
Tan. lat. -	51	32		10.0999135
Tan. declin. -	17	42		9.5039822
Aſcen. diff. -	23	41	Sin.	9.6038957

	h.	m.	s.
In time -	— 1	34	44
	6	0	0
	4	25	16
Correction -	—	2	38
Semidiurnal arch	4	22	38

4. For the correction. The equat. = 4m. 5s.

	′	″
Moon's horizontal paral. - -	54	23
Refraction - - -	— 33	0
	21	23

As 33′ : 4m. 5s. : : 21′ 23″ : 2m. 38s. = corr.

5. Moon's

	h.	m.	s.
5. Moon on the mer. at	9	12	36
Semidiurnal arch -	+ 4	22	38
Moon ſets at -	13	35	14 or 1 h. 35 m. paſt midnight

EXAM. 3. Required the time of moon's riſing at Edinburgh, lat. 56° N. July 24th, 1796? *Anſ.* 10h. 28m.

At noon. Sun's long. 4s. 2° 10′ 55″ R. A. 8h. 17m. 48s.

Moon's long. 11s. 23° 22′ 21″, lat. 5° 1′ 8″ S. Declin. 7° 14′ 27″ S.

	h.	m.	s.
And R. aſcenſion - -	23	43	40
Sun's - - -	— 8	17	48
Eſtimat. moon on meridian -	15	25	52

	h.	m.	s.
1. At 15 h. 26 m. moon's R. A. is -	0	14	17
Sun's - -	— 8	20	20
Moon on the meridian - -	15	53	57

By calculating again for this time, the moon is on the meridian at 15 h. 54 m. 52 s.

2. To latitude 56° N. and declination 7° S. the ſemidiurnal arch is 5 h. 18 m. which being ſubtracted from 15 h. 55 m. there remains 10 h. 37 m. for the eſtimate time of moon's riſing.

3. The diff. of the moon's declination in 12 hours is 2° 27′ decreaſing.

As 12h. : 2° 27′ : : 10h. 37m. : 2° 10′.

	°	′	
Moon's declin. at noon - -	7	14	S.
Subtract - - -	— 2	10	
Declin. at riſing - -	5	4	S.

4. For

4. For the moon's femidiurnal arch.

	° ′		
Tan. lat -	56 0		10.1710126
Tan. declin. -	5 4		8.9477338
Aſcen. diff. -	7 33	Sin.	9.1187464

	h.	m.	s.
In time -	— 0	30	12
	6	0	0
Semidiur. arch	5	29	48
Correction -	—	2	53
	5	26	55

For the correction.

	′	″
Moon's horizontal parallax -	56	51
Refraction - - -	— 33	0
	23	51

As 33′ : 4m. : : 23′ 51″ : 2m. 53s.

	h.	m.	s.
5. Moon on the meridian at -	15	54	52
Semidiurnal arch - -	— 5	26	55
Moon riſes at - - -	10	27	57

4. Required the apparent time of the moon's riſing at Edinburgh, latitude 56° N. and longitude 3° 6′ 15″ W. Sept. 10th 1797? *Anſ.* 8h. 25m.

At midnight ſun's longitude is 5s. 18° 41′ 3″, R. A. 11h. 18m. 5s.

Moon's longitude 1s. 11° 58′ 12″, latitude 2° 55′ 22″ S. and declin. 12° 39′ 24″ N.

	h.	m.	s.
At midnight moon's R. A. -	2	41	50
Sun's ditto - - -	11	18	5
Eſtimate ☽ on merid. - -	15	23	45

Moon's

	h.	m.	s.
Moon's R. A. at 12h. -	= 2	41	50
For 3h. 24m. add - -	+ 7	2	
Moon's R. A. on the merid. -	2	48	52
Sun's ditto - -	— 11	18	35
Moon on the merid. at - -	15	30	17
To lat. 56° N. and decl. 12° 39′ N. the semid. arch - -	— 7	18	0
Estimate time of moon's rising -	8	12	0

The difference of moon's declination in 12h. is 2° 20′.
As 12h. : 2° 20′ : : 7h. 18m. : 1° 25′.

	°	′
Moon's declination at midnight -	12	39
Subtract - - -	— 1	25
Moon's declin. at rising - -	11	14

	°	′	″	
Tan. latitude -	56	0	0	10.1710126
Tan. declination	11	14	0	9.2980011
Ascens. diff. -	17	2	20	Sin. 9.4690137

	h.	m.	s.	
In time -	1	8	9	20
Add -	6	0	0	
Semidiurnal arch	7	8	9	
Correction -	— 3	1		
	7	5	8	

For correcting the semidiurnal arch. The equation is 4m. 14s.

	′	″
Moon's horizontal parallax -	56	35
Refraction - - -	— 33	0
Difference -	23	35

As 33′ : 4m. 14s. : 23′ 35″ : 3m. 1s.

Moon

	h.	m.	s.
Moon on the meridian at -	15	30	17
Correct ſemidiurnal arch - -	— 7	5	8
Moon riſes at - -	8	25	9

CHAP. VII.

Calculation of the Mean and True Syzygies.*

PROB. XXX. *To find the Time of the Mean Syzygies in any given Year and Month.*

FROM the Tables of the mean motion of the moon from the ſun, p. 70, 71. take out the motions for the given year and month; add them, and ſubtract the ſum from 12 ſigns: then, if the time of mean conjunction or new moon be ſought, the remainder, or the neareſt leſs than it, being found in the Table of days, will give the day of mean new moon; and after ſubtracting the number found in the Table, the remainder or the next leſs is to be found in the Table of hours, which will give the hour of the day when it is mean new moon; and after another ſubtraction, the remainder is to be found in the Table of minutes for the minute of mean new moon,

* *By the* times of mean ſyzygies *are underſtood ſuch times of new and full moons as would happen if the orbits of the earth and moon were perfect circles, and their motions always uniform in them.*

moon, and the next remainder will give the ſeconds. But if the time of mean oppoſition or full moon be ſought, add 6 ſigns to the firſt remainder, and the ſum being found in the Table of days, will give the day of mean full moon: the hours and minutes are to be found as before.

EXAM. 1. Required the time of mean new moon in January 1797? *Anſ.* Jan. 27d. 7h. 40m. 21s.

		S.	°	′	″	
1797		— 0	26	57	10	
		12	0	0	0	
Remains		11	3	2	50	
27 days		— 10	29	9	0	
			3	53	50	
7 hours		—	3	33	20	
				20	30	
40 minutes		—		20	19	5″′
21 ſeconds					10	55

In this operation the Tables give the moon's mean diſtance from the ſun on the 1ſt day of January 0s. 26° 57′ 10″, which is ſubtracted from 12 ſigns to find how much the moon wants of a conjunction with the ſun: the remainder ſhows that ſhe wants 11s. 3° 2′ 50″. In the Table of days it is found that ſhe moves over 10s. 29° 9′ in 27 days; therefore the mean new moon happens on the 27th day of January.

Subtract 10s. 29° 9′ from 11s. 3° 2′ 50″, there remains 3° 53′ 50″, which in the Table of hours gives 7 hours; and ſubtracting 3° 33′ 20″, there remains 20′ 30″, which gives 40 minutes; and by ſubtracting again there remains 10″ 55‴, and this gives 21 ſeconds.

2. It

2. It is required to find the time of mean full moon in January 1797? *Anſ.* Jan. 12d. 13h. 18m. 18s.

	S.	°	′	″
1797	— 0	26	57	10
	12 , 0	0	0	0
	11	3	2	50
Add	- 6	0	0	0
	5	3	2	50
12 days	— 4	26	17	20
		6	45	30
13 hours	- —	6	36	12
			9	18
18 minutes		—9	8	35
18 ſeconds	-		9	25

3. Required the time of mean conjunction or new moon in July 1797? *Anſ.* July 23d, 12 h. 5m.

	S.	°	′	″
1797	- 0	26	57	10
July	- 1	16	31	22
Subtract	— 2	13	28	32
From	- 12	0	0	0
	9	16	31	28
23 days	— 9	10	23	13
		6	8	15
12 hours		— 6	5	43
			2	32
4 minutes	-		2	1 54
59 ſeconds	-		30	6

4. What is the time of mean oppoſition or full moon in July 1797? *Anſ.* July 8d. 17h. 42m. 57s.

	S.	°	′	″
1797 - -	0	26	57	10
July - -	1	16	31	22
Subtract -	— 2	13	28	32
From - -	12	0	0	0
	9	16	31	28
Add - -	6	0	0	0
	3	16	31	28
8 days - -	— 3	7	31	33
		8	59	55
17 hours -	— 8	38	6	
		21	49	
42 minutes - -	— 21	20	2	
57 ſeconds - -			28	58

In place of ſubtracting the firſt ſum from 12 s. and adding 6s. to the remainder, it will be as good to ſubtract the firſt ſum from 6s. and the remainder will give the anſwer.

By this problem the times of mean new and full moon may be calculated for every month in the year, or any longer time, with very little trouble; for having found the time of mean conjunction and oppoſition in the month of January, add to theſe times a mean lunation, viz. 29d. 12h. 44m. 3s. continually, rejecting the days in the month wherein the mean new or full moon is required, and the times will be known.

EXAM. Let it be required to find the mean new and full moons in every month of the year 1797?

Mean full moon.	D.	h.	m.	s.	Mean new moon.	D.	h.	m.	s.
January -	12	13	18	18	January -	27	7	40	21
One lunation +	29	12	44	3	One lunation +	29	12	44	3
February -	11	2	2	21	February -	25	20	24	24
March -	12	14	46	24	March -	27	9	8	27
April -	11	3	30	27	April -	25	21	52	30
May -	10	16	14	30	May -	25	10	36	33
June -	9	4	58	33	June -	23	23	20	36
July -	8	17	42	36	July -	23	12	4	39
Auguſt -	7	6	26	39	Auguſt -	22	0	48	42
September -	5	19	10	42	September -	20	13	32	45
October -	5	7	54	45	October -	20	2	16	48
November -	3	20	38	48	November -	18	15	0	51
December -	3	9	22	51	December -	18	3	44	54

Note

Note: The mean and true ſyzygies never happen at the ſame time except when the moon is in or very near her apogee or perigee; for in theſe points many of her inequalities either vaniſh or are very ſmall: when the moon is in any other point of her orbit, there is ſome interval of time between the mean and true conjunctions or oppoſitions. The greateſt is about 14 hours.

PROB. XXXI. *The Time of Mean Conjunction or New Moon being given, to find the true Time.*

CALCULATE the longitudes of both ſun and moon for the time of mean conjunction (Prob. V.—XIII.), and if they are equal to one another, the mean and true conjunctions happen at the ſame time; but if they differ, ſubtract the leaſt from the greateſt. Find the hourly motions of both ſun and moon at the time (Prob. VII—XVIII.), and ſubtract the ſun's hourly motion from the moon's, the remainder is the hourly motion of the moon from the ſun; and then,

As the moon's hourly motion from the ſun
Is to one hour or 60 minutes;
So is the difference between the ſun and moon's long.
To the time between the mean and true conjunction.

If the moon's longitude be leſs than the ſun's, the interval is to be added to the time of mean conjunction; but if it be greater, ſubtract the interval: the ſum or remainder is the time of true conjunction.

When it is required to find the time of true conjunction very accurately, the ſun and moon's longitude muſt be calculated again for the time found; and their difference, if there be any, turned into time, and applied to the time laſt found, will give the true time of conjunction.

If the difference be great, it will be neceſſary to renew the operation again.

EXAM. I.

EXAM. 1. It is required to find the time of true conjunction in January 1797; the time of mean conjunction or new moon being January 27th, 7h. 40m. 21s. in the meridian of Greenwich? *Anſ.* Jan. 27d. 13h. 40m.

The ſun's longitude then is 10s. 8° 28′ 38″, and his mean anomaly 6s. 28° 3′ 51″.

For the Moon's Longitude.

m. Long.					Apogee.				☊			
	S.	°	′	″	S.	°	′	″	S.	°	′	″
1797 -	10	7	34	43	0	24	6	53	3	1	15	6
Jan. 27th -	11	25	45	46	11	22	45	17				
7h. -		3	50	35		3	48	38	—	1	25	47
40m. -			21	57			21	46				56
21s. -				11				11				5
	10	7	33	12	0	21	2	45	2	29	48	18
10 equations		+	25	18		—	10	25		—	4	25
	10	7	58	30	0	20	52	20	2	29	43	53
Equat. of centre	—	2	9	7		+	25	18				
	10	5	49	23	0	21	17	38	= 11th arg.			
Variation -		—	3	15								
	10	5	46	8								
13th -		—	1	5								
☽'s orb. long.	10	5	45	3								
☉'s long. -	10	8	28	38								
Short of conj.		2	43	35								

Arguments.

	Arguments.			
	S.	°	′	″
1	6	28	3	51
2	5	26	12	59
3	5	0	5	17
4	0	19	11	53
5	11	7	7	6
6	6	5	10	14
7	4	8	2	32
8	5	22	58	54
9	11	8	1	49
10	4	21	19	40
12	11	27	20	45
13	1	29	46	52

	Equations.			
	+	′	″	′ ″
1				5 15
2				0 4
3				0 38
4		0	19	
5		30	53	
6				0 11
7		0	37	
8		0	5	
9		0	31	
10				0 59
	+	32	25	7 7
	−	7	7	
Sum	+	25	18	

	′	″
Moon's hourly motion -	29	47
Sun's ditto - - -	2	33
Hourly motion ☽ *à* ☉ - -	27	14

As 27′ 14″
To 1 h.
So 2° 43′ 35″
To 6 h. 0 m. 24 s.

	D.	h.	m.	s.
Mean conjunction January -	27	7	40	21
Interval add - -	+	6	0	24
Anſ. New moon January -	27	13	40	45

The time of true oppoſition or full moon is found in the ſame manner as the time of conjunction. The operation is to be continued until the difference of the ſun and moon's longitude be 6 ſigns.

2. Re-

2. Required the time of oppoſition, or full moon, in January, 1797? The time of mean full moon is January 12d. 13h. 18m. 18s.

The ſun's longitude then is 9s. 23° 27′ 34″, and his mean anomaly 6s. 13° 30′ 42″.

For the Moon's Longitude.

	m. Long.				Apogee.				☊			
	s.	°	′	″	s.	°	′	″	s.	°	′	″
1797 -	10	7	34	43	0	24	6	53	3	1	15	6
Jan. 12th -	5	8	7	0	5	6	46	47				
13h. -		7	8	14		7	4	37	—	0	38	8
18m. -			9	53			9	48			1	43
18s. -				10				10				2
	3	23	0	0	6	8	8	15	3	0	35	13
10 equat. -		—	16	19		—	5	11		—	2	11
	3	22	43	41	6	8	3	4	3	0	33	2
Equat. of centre		+	54	54		—	16	19				
	3	23	38	35	6	7	46	45	= arg. 11th			
Variation -			+	14								
	3	23	38	49								
13th -			—	51								
☽'s orbit long.	3	23	37	58								

Equations.

Equations.

	+	—
	′ ″	′ ″
1		2 40
2	11	
3		0 19
4		0 7
5		12 48
6	10	
7		0 15
8		0 3
9	15	
10		0 43
	0 36	—16 55
		+ 0 36
	Sum	— 16 19

Arguments.

	S.	°	′	″
1	6	13	30	42
2	6	12	35	34
3	5	15	34	10
4	6	7	13	7
5	5	20	56	37
6	0	4	27	19
7	11	7	25	55
8	11	24	37	37
9	11	21	24	11
10	5	7	7	39
12	6	0	11	1
13	7	8	24	49

	S.	°	′	″
Moon's orbit long.	—3	23	37	58
Sun's long.	9	23	27	34
	5	29	49	36
Paſt oppoſition	0	0	10	24

	′	″
Moon's hourly motion	37	9
Sun's ditto	2	33
☽'s hourly motion from ⊙	34	36

	L. L.
As 34′ 36″	2391
To 60m.	0
So 10′ 24″	7611
To 18m. 2s.	5220

From

	D.	h.	m.	s.
From the mean oppoſition -	12	13	18	18
Subtract the interval -			—18	2
True time of full moon Jan.	12	13	0	16

The rules here given for calculating the times of new and full moon are always good; but the tedioufneſs of the operation has given occaſion to the invention of other tables, whereby the problem may be ſolved with leſs trouble. The beſt of theſe were publiſhed among Dr Halley's aſtronomical tables in the year 1749, but not as his invention. The ingenious Mr James Ferguſon having adapted them to the Gregorian ſtyle, and made ſome alterations in the arrangement, printed them in his Aſtronomy about the year 1760. Such of them as were judged proper for this work are to be found in p. 121—127, &c. where the table of years is extended to 1821.

Theſe tables contain the times of mean conjunction or new moon in March for every year, which is made the firſt month with the mean anomalies of the ſun and moon, and alſo the ſun's mean diſtance from the moon's node at the time, with equations for reducing the mean to the true time of conjunction or oppoſition, whereby theſe times may be found for any month of a given year within the limits of the Table.

PROB. XXXII. *To Calculate the Time of New or Full Moon for any Month of a given Year by the Tables*, p. 121—123.

1ſt, For the Month of March.

WRITE down the time of mean new moon in March for the given year, with the mean anomalies of the ſun and moon, and alſo the ſun's mean diſtance from the moon's aſcending node, out of the Table, p. 121.

When

When the time of Full Moon in March is required.

If the new moon happens before the 15th of the month, add half a lunation, with the anomalies, &c. to the former numbers for new moon, the ſum is the time of full moon; but if it happens after the 15th, ſubtract half a lunation with the anomalies from the numbers for new moon, and the time of mean full moon in March will be known.

2d, For any Month after March.

When the time of the mean new or full moon is required in any month after March, take out the numbers for March as before, and under them write down as many lunations with their anomalies as the given month is after March; and by the ſum of theſe, the time of mean new or full moon may be known, together with the mean anomalies and the ſun's diſtance from the moon's node; which are the arguments for finding the ſeveral equations, to reduce the time of the mean ſyzygies to the true.

With the ſum of the days enter the Table of days, p. 123. under the given month; and oppoſite to that number in the left hand column is the day of the mean ſyzygies; but if the ſum be leſs than any of thoſe under the given month, add a lunation with the anomalies to the former numbers, and then enter the Table with the ſum under the given month, and in the left hand column is the day of the month required.

The time of mean ſyzygy being known, to find the true by the Tables, p. 124—127.

1. With the ſun's mean anomaly enter the Table, p. 124. and take out the firſt equation (making proportion for the odd minutes, &c.), and apply it to the time of the mean ſyzygy, according to its ſign.

2. With the ſun's mean anomaly take the equation of the moon's mean anomaly out of the Table, p. 125. and apply it according to its ſign, and the moon's equated anomaly will be known.

3. With the moon's equated anomaly take the ſecond equation out of the Table, p. 126. which being applied to the former time, according to its ſign, the reſult will be the time of the ſyzygy very nearly.

4. Subtract the moon's equated anomaly from the ſun's mean anomaly, and with the remainder take the third equation out of the Table, p. 127. and apply it to the former equated time according to its ſign.

Laſtly, with the ſun's mean diſtance from the moon's node take the fourth equation out of the Table, p. 127. and apply it to the laſt found equated time, according to its ſign, and the reſult is the time of the true ſyzygy.

EXAM.

EXAM. 1. It is required to find the time of new moon in January 1797?

	D. h. m. s.	Sun's anom. S. ° ′ ″	D's anom. S. ° ′ ″	D's ☊. S. ° ′ ″
1796, March -	8 11 39 44	8 8 3 47	3 7 2 14	8 0 26 47
11 lunations -	324 20 4 33	10 20 9 33	9 13 59 5	11 7 22 34
1797, January -	27 7 44 17	6 28 13 20	0 21 1 19	7 7 49 21
1st equation -	+ 2 0 53	—0 21 46 23	Equa. +45 4	arg. 4th equat.
-	+			
-	27 9 45 10	6 6 26 57	0 21 46 23	
2d equation -	+ 3 52 3	arg. 3d equat.	arg. 2d equat.	
	27 13 37 13			
3d equation -	+ 32			
4th equation -	+ 1 30			
Ans. January -	27 13 39 15	or Jan. 28. at 1h. 39m. morning, civil account.		

In this example, when ten lunations were added to the numbers for March, the sum of the days was 304, which is less than any of these under January; and therefore 11 lunations are added, and then the sum of the days is 333, which is found under Jan. opposite to 27 in the left hand column, which shows that the new moon happens on the 27th of the month, astronomical time, wherein the day begins and ends at noon.

2. Required

2. Required the time of full moon in January 1797?

	D.	h.	m.	s.	☉'s anom. S.	°	′	″	☽'s anom. S.	°	″	″	☉'s dist. from ☊. S.	°	′	″
1796, March -	8	11	39	44	8	8	3	47	3	7	2	14	8	0	26	47
½ lunation - +	14	18	22	2	0	14	33	10	6	12	54	30	0	15	20	7
Full ☽ in March	23	6	1	46	8	22	36	57	9	19	56	44	8	15	46	54
Add 10 lunations	295	7	20	30	9	21	3	14	8	18	10	4	10	6	42	20
1797, January -	12	13	22	16	6	13	40	11	6	8	6	48	6	22	29	14
1st equation -	+ 1	0	30		−6	8	29	38	+	22	50		arg. 4th equat.			
	12	14	22	46	0	5	10	33	6	8	29	38				
2d equation -	— 1	20	45		arg. 3d equat.				arg. 2d equat.							
	12	13	2	1												
3d equation -		—		26												
4th equation -		+ 1	6													
Ans. January -	12	13	2	41												

3. It

3. It is required to find the time of new moon in July 1797?

	D. h. m. s.	☉'s anom. s. ° ′ ″	☽'s anom. s. ° ′ ″	☉'s dist. à ☽'s ☊. s. ° ′ ″
1797, March --	27 9 12 24	8 26 25 59	2 12 39 19	9 9 9 48
4 lunations -	118 2 56 12	3 26 25 17	3 13 16 2	4 2 40 56
July - -	23 12 8 36	0 22 51 16	5 25 55 21	1 11 50 44
1st equation - -	— 1 35 35	—5 25 19 3	— 36 18	arg. 4th equat.
	23 10 33 1	6 27 32 13	5 25 19 3	
2d equation -	+ 44 43	arg. 3d equat.	arg. 2d equat.	
	23 11 17 44			
3d equation -	+ 2 11			
4th ditto - -	+ 1 33			
New ☽ July -	23 11 21 28			

4. Required

4. Required the time of full moon in July 1797?

	D.	h.	m.	s.	Sun's anom. S.	°	′	″	Moon's anom. S.	°	′	″	☉'s dist. à ☽'s ☊. S.	°	′	″
1797, new ☽ in Mar.	27	9	12	24	8	26	25	59	2	12	39	19	9	9	9	48
½ lunation -	—14	18	22	2	—	14	33	10	—6	12	5	430	—	15	20	10
Full ☽ in March	12	14	50	22	8	11	52	49	7	29	44	49	8	23	49	38
4 lunations -	118	2	56	12	9	3	26	25	17	3	13	16	2	4	2	40	56
Full ☽ July - -	8	17	46	34	0	8	18	6	11	13	0	51	0	26	30	34
1st equation -	—	35	27		11	12	47	26	—		13	25				
	8	17	11	7	0	25	30	40	11	12	47	26				
2d equation - -	—	3	6	14	arg. 3d equat.				arg. 2d equat.							
	8	14	4	53												
3d equation -	—	2	2													
4th ditto - -	+	1	15													
Ans. July -	8	14	4	6												

5. Required

5. Required the time of conjunction or new moon in May 1798?

	D.	h.	m.	s.	Sun's anom. S.	°	′	″	Moon's anom. S.	°	′	″	☉'s dist. à ☽'s ☊. S.	°	′	″
1798, new ☽ March	16	18	1	1	8	15	41	51	0	22	27	25	9	17	12	35
2 lunations -	59	1	28	6	1	28	12	39	1	21	38	1	2	1	20	28
May -	14	19	29	7	10	13	54	30	2	14	5	26	11	18	33	3
1st equation -	+	2	58	10	−2	15	13	0	+	1	7	34	arg. 4th, equat.			
	14	22	27	17	7	28	41	30	2	15	13	0				
2d equation -	+	9	37	38	arg. 3d, equat.				arg. 2d, equat.							
	15	8	4	55												
3d equation -		+	4	8												
4th ditto -		−		37												
Anſ. May =	15	8	8	26												

2. It

6. It is required to calculate the time of oppoſition, or full moon, in November 1800?

	D.	h.	m.	s.	☉'s Anomaly. S.	°	′	″	☽'s Anomaly. S.	°	′	″	☉'s diſt. and ☽'s ☊. S.	°	′	″
1800, March -	25	0	22	17	8	23	19	55	10	7	52	36	11	3	58	24
½ luna. ſubtract.	—14	18	22	2	—14	33	10		—6	12	54	30	—15	20	7	
Full ☽ in Mar.	10	6	0	15	8	8	46	45	3	24	58	6	10	18	38	17
8 luna. - +	236	5	52	24	+7	22	50	35	+6	26	32	3	+8	5	21	52
Nov. -	1	11	52	39	4	1	37	20	10	21	30	9	6	24	0	9
1ſt equat. -	—	3	35	57	—10	20	8	25	—1	21	44		arg. 4th equat.			
	1	8	16	42	5	11	28	55	10	20	8	25				
2d equat. -	—	6	37	56	arg. 3d equat.				arg. 2d equat.							
	1	1	38	46												
3d equat. -		—	1	33												
4th - -		+	1	10												
Anſ. Nov. -	1	1	38	23												

7. It

7. It is required to find the time of conjunction, or new moon, in the month of Auguſt, 1820?

	D.	h.	m.	s.	☉'s Anomaly. s.	°	′	″	☽'s Anomaly. s.	°	′	″	☉'s diſt. and ☽'s Ω. s.	°	′	″
1820 March	14	1	42	45	8	12	25	31	6	24	37	23	11	19	35	34
5th luna. -	147	15	40	15	4	25	31	37	4	9	5	2	5	3	21	10
Auguſt -	8	17	23	0	1	7	57	8	11	3	42	25	4	22	56	44
1ſt equat. -	—	2	31	47	—11	2	44	51		—	57	34	arg. 4th equat.			
	8	14	51	13	2	5	12	17	11	2	44	51				
2d equat. -	—	4	47	7	arg. 3d equat.				arg. 2d equat.							
	8	10	4	6												
3d equat. -			—	4	27											
4th -			—	1	29											
Anſ. Aug. -	8	9	58	10												

Note 1. Theſe examples are wrought for the meridian of Greenwich; but the anſwers may be reduced to the time under any other meridian by adding or ſubtracting the difference of longitude in time to or from them, according as the place is ſituated to the eaſt or weſt of Greenwich.

2. These tables give the times of new and full moon with little trouble, and sufficiently true for common use; being rarely above 1 or 2 minutes wide of the truth: but when it is required to find the moment of conjunction or opposition accurately, calculate the longitudes of the sun and moon for the time found by the tables; and if they are the same, or differ 6 signs, according as the new or full moon is required, the time is truly found; but if not, take their difference. Find the hourly motion of the moon from the sun; and then,

As the hourly motion of the moon from the sun
Is to 60 minutes;
So is the difference between the sun and moon's long.
To a number of minutes, &c.

which, applied to the time formerly found, will give the true time.

3. The precise moment of conjunction or opposition is seldom necessary except in calculating eclipses.

4. In the preceding examples the time of orbit conjunction or opposition is taken for the answer; that is, the time when the moon's longitude in her orbit is the same with the sun's longitude in the ecliptic, is taken for the time of conjunction; and the time when the moon's orbit longitude differs 6 signs from the sun's longitude, is taken for the time of opposition.

All the answers are in mean time; and if the equation of time be applied to them with a contrary sign to that in the table, the apparent time will be known.

To calculate more accurately the time of new moon in August 1820: The answer by our tables is August 8 d. 9 h. 58m. 10s. The sun's longitude at this time is 4s. 16° 9′ 44″, and his mean anomaly 1 s. 7° 23′ 13″.

The

The calculation of the moon's longitude for the same time follows.

	☽'s m. Long.				☽'s anom.				☽'s ☊.			
	S.	°	′	″	S.	°	′	″	S.	°	′	″
1820 -	3	19	18	47	11	0	1	6	0	6	25	42
August 8th	0	18	48	26	11	24	17	51				
9 h. -		4	56	28		4	53	58	—	11	39	0
58 m. -			31	50			31	34		—	1	12
10 s.				5				5			—	7
	4	13	35	36	10	29	44	34	11	24	45	23
10 equations		—	25	26		+	12	54		+	5	28
	4	13	10	10	10	29	57	28	11	24	50	51
Equat. centre	+	3	1	4		—	25	26				
	4	16	11	14	10	29	32	2				
Variation -			+	1	arg. 11th.							
	4	16	11	15								
13th equation		—	1	1								
☽'s orb. long.	4	16	10	14								
Sun's long. -	4	16	9	44								
Difference -				30								

Arguments.

	Arguments.	Equations.	
		+	−
	S. ° ′ ″	′ ″	′ ″
1	1 7 23 13	6 37	
2	1 2 14 57		0 29
3	10 17 28 31	0 51	
4	10 24 36 18		0 36
5	0 25 7 10		33 43
6	2 2 30 23	1 49	
7	11 17 43 57		0 10
8	9 22 21 21		0 39
9	9 2 40 29		0 3
10	7 8 35 39	0 57	
			35 40
12	0 0 1 30	+10 14	+10 14
13	10 13 8 46		−25 26

		′ ″
Moon's hourly motion	-	28 54
Sun's ditto	-	2 24
Hourly motion ☽ *à* ☉	-	26 30

	L. L.
As 26′ 30″	3549
To 60m.	0
So is 30″	20792
To 1m. 7s.	17243

	D.	h.	m.	s.
Former time Auguſt -	8	9	58	10
Interval ſubtract - -			− 1	7
True time of new moon -	8	9	57	3

which is nearly the ſame with the former.

CHAP.

CHAP. VIII.

Of Eclipſes. To predict the Times of Eclipſes, and their Number in any given Year. Calculation of Eclipſes.

IF the rays of light iſſuing from a lucid body fall upon an opaque body, the opaque body intercepts them, and thereby renders a certain ſpace beyond it dark; and this dark ſpace is called the *ſhadow of the opaque body*, whoſe form varies with the figure and magnitude of the opaque body.

If the lucid and opaque bodies are equal globes, the ſhadow of the opaque will be a cylinder of an unlimited length. If the opaque be greater than the lucid, its ſhadow will be the fruſtum of an immenſe cone, the diameter of its baſe increaſing with its length; and if the opaque body be leſs than the lucid, its ſhadow will be a cone.

All the great bodies in the ſolar ſyſtem are ſpherical. The ſun is the only lucid body in his ſyſtem, affording light and heat to all the planets; which being opaque bodies, ſhine by reflecting the ſun's light that falls on them: and becauſe the ſun is a much larger body than any of the planets, their ſhadows are conical, each of them ending in a point. The lengths of the ſhadows of the planets differ according to their ſeveral magnitudes.

If any planet A paſſes through the ſhadow of another B it is deprived of the ſun's light in whole or in part; and a ſpectator on A would ſee the ſun eclipſed, while at the ſame time

a ſpectator on the planet B would ſee the planet A eclipſed. If any planet was equal to or greater than the ſun, its ſhadow would extend farther than the moſt diſtant of the reſt, and ſo eclipſe them as they paſſed through it; but it is known that none of the ſhadows of the primary planets extend to that next it; and therefore the primary planets do not eclipſe each other. It is only the primary planets and their ſatellites that eclipſe each other, and the ſun to either.

The only eclipſes that fall moſt directly under our obſervation are thoſe of the ſun and moon; and the prediction and calculation of theſe is a conſiderable part of practical aſtronomy.

The ſun is eclipſed when the moon comes between the earth and ſun, and intercepts his light ſo that the whole or ſome part of the ſun's diſc appears dark; and this happens only at the time of conjunction or new moon.

The moon is eclipſed when the earth, coming between the ſun and moon, intercepts the ſun's light, and prevents it from falling on the moon, ſo that her diſc is wholly or partly dark; and this happens only at the time of oppoſition or full moon.

If the moon's orbit was in the ſame plane with the ecliptic, there would be a central eclipſe of the ſun at every conjunction or new moon, and a total eclipſe of the moon at every oppoſition or full moon; for then the moon, being always in the ecliptic, the centres of the ſun, earth, and moon, would be always in the ſame ſtraight line at theſe times. But becauſe the moon's orbit is inclined to the ecliptic, and forms an angle with it of about $5\frac{1}{3}$ degrees, the moon is never in the ecliptic, except when ſhe is in one of her nodes; and therefore there are many conjunctions and oppoſitions of the ſun and moon without any eclipſe.

The moon is always at ſome diſtance from the ecliptic, except when ſhe is in one of her nodes; and this diſtance is called *her latitude*, which is north or ſouth, according as the moon is on the north or ſouth ſide of the ecliptic.

There

There cannot be a central eclipſe of the ſun unleſs the moment of conjunction happen when the moon is in one of her nodes; which happens but ſeldom. And becauſe the ſection of the earth's ſhadow, through which the moon paſſes at the time ſhe is eclipſed, is much larger than the moon's diameter; the moon may be totally eclipſed when ſhe is at a ſmall diſtance from her node.

There is ſome difference between a central and total eclipſe of the ſun; for the ſun is centrally eclipſed to ſome part of the earth, when the moon is in her node, at the time of conjunction; but if at the ſame time the earth be at its greateſt diſtance from the ſun, the moon's ſhadow will be leſs than the ſun's diſc, and cover only a part of it about the centre; a lucid ring will appear round the part obſcured; and ſuch are called *annular eclipſes;* which happen very rarely. But if, at the time of conjunction, the earth be at its leaſt diſtance from the ſun, and the moon in perigee, her ſhadow will cover the whole diſc of the ſun. In ſuch a ſituation the ſun is totally eclipſed; but ſuch an eclipſe does not happen above once in ſeveral centuries. Hence eclipſes are central, total, or partial, according to the ſituation of the earth and moon with reſpect to the ſun and to one another.

PROB. XXXIII. *To find out the number of Eclipſes there are in any given year, and in what months and days they happen.*

FROM the Table of the moon's means motion, p. 30. take out the mean longitude of the moon's nodes for the given year; and then by the Table of the ſun's longitude for every day of the year, p. 25. find when the ſun's longitude will be nearly the ſame with that of the nodes, for at theſe times the eclipſes muſt happen. The months when the ſun is in or near the places of the nodes may be called the *node-months.*

In

In this inquiry it may be proper to remember that the moon's nodes move backward about 1° 38′ every month.

To find the Days when Eclipſes happen.

Calculate the times of the mean ſyzygies in the node-months out of the Tables, p. 121, &c. and alſo the ſun's diſtance from the moon's node; and if the ſun's diſtance from the node at the time of new moon be leſs than 18 degrees, an eclipſe of the ſun may be expected; and if the ſun's diſtance from the node at the time of full moon be leſs than 12 degrees, there may be an eclipſe of the moon. We ſay there may be, becauſe we ſpeak only of mean motions here.

EXAM. 1. It is required to find the number of eclipſes in the years 1796; and on what days they happen?

The mean longitude of the moon's north node, on the 1ſt of January 1796, is 3s. 20° 35′ and of the ſouth node 9s. 20° 35′. The ſun enters the ſign Cancer about the 20th of June, and the ſign Capricorn about the 22d of December; therefore the node-months are January, July, and December.

1. Calculate the time of mean new moon in January.

New moon.	D.	h.	m.	s.	☉'s diſt. from ☽'s ☊.	s.	°	′	″
1795, March	20	2	51	8		7	22	24	0
10 lunats. +	295	7	20	30		10	6	42	20
New ☽ 1796 Jan.	9	10	11	38		5	29	6	20 ſun eclipſed.

The ſun's mean diſtance from the moon's north node being 5s. 29° 6′ 20″, his diſtance from the ſouth node is only 53′ 40″; and therefore the ſun will be eclipſed to ſome place of the earth.

2. For

2. For the time of mean new moon in July.

New moon.	D.	h.	m.	s.	☉'s dist. from ☽'s ☊.	s.	°	′	″
1796, March	8	11	39	44		8	0	26	47
4 lunations +	118	2	56	12		4	2	40	56
New ☽ July	4	14	35	56		0	3	7	43 sun eclipsed.

3. For the time of mean full moon in December.

New moon.	D.	h.	m.	s.	Sun's dist. from ☊.	S.	°	′	″
1796, March	8	11	39	44		8	0	26	47
½ lunation +	14	18	22	2		+ 15	20	7	
Full ☽ in Mar.	23	6	1	46		8	15	46	54
9 lunations +	265	18	36	27		+ 9	6	2	6
Full ☽ Dec.	14	0	38	13		5	21	49	0 moon eclipſ.

The ſun's diſtance from the moon's north node being 5s. 21° 49′, the moon's diſtance from her ſouth node is only 8° 11′, and therefore ſhe is eclipſed.

4. For the time of mean new moon in December.
Add ½ lunation to the numbers for full moon.

New moon.	D.	h.	m.	s.	Sun's dist. from ☊.	S.	°	′	″
Full ☽ Dec.	14	0	38	13		5	21	49	0
½ lunation +	14	18	22	2		+ 15	20	7	
New ☽ Dec.	28	19	0	15		6	7	9	7 sun eclipſed.

We have found that there are four eclipſes in the year 1796, viz. three of the ſun and one of the moon. The times of the mean conjunctions and oppoſition are:

		D.	h.	m.	s.
Sun is eclipſed -	Jan.	9	10	11	38
	July	4	14	35	56
	Dec.	28	19	0	15
And the moon is eclipſed -		—14	0	38	13

2. Required the number of eclipſes in the year 1797, and the days when they happen?

The mean longitude of the moon's north node, in January 1797, is 3 s. 1° 15′; and of her ſouth node 9 s. 1° 15′; therefore the node months are June and December.

1. Calculate the time of mean conjunction and oppoſition in June.

New Moon.	D.	h.	m.	s.	Sun's diſt. from ☊.	s.	°	′	″	
1797, March	27	9	12	24		9	9	9	48	
3 lunations	88	14	12	9		3	2	0	42	
New ☽ June	23	23	24	33		0	11	10	30	ſun eclipſed
Subt. ½ lun.	—14	18	22	2		—15	20	7		
Full ☽ June	9	5	2	31		11	25	50	23	moon eclipſed.

2. Calculate the time of mean conjunction and oppoſition in December.

New Moon.	D.	h.	m.	s.	Sun's diſt. from ☊.	s.	°	′		
1797, March	27	9	12	24		9	9	9	48	
9 lunations +	265	18	36	27	+	9	6	2	6	
New ☽ Decem.	18	3	48	51		6	15	11	54	ſun eclipſed
Subt. ½ lun.	—14	18	22	2		—15	20	7		
Full ☽ Decem.	3	9	26	49		5	29	51	47	moon eclipſed.

There

There will be four eclipſes in the year 1797: two of the moon and two of the ſun.

	D.	h.	m.
The moon will be eclipſed June -	9	5	3
And December - - -	3	9	27
The ſun will be eclipſed June -	23	23	25
And December - -	18	3	50

According to mean motions; but the true times differ ſeveral hours from theſe.

In the ſame manner we find that there will be four eclipſes in the year 1798, *viz.*

				☉'s diſt from ☊.		
	D.	h.	m.	s.	°	′
Of the ſun May -	14	19	29	11	18	33
Of the moon ditto -	29	13	51	0	3	53
Of the ſun November -	7	23	53	5	22	34
Of the moon ditto -	22	18	15	6	7	54

Of viſible and inviſible Eclipſes.

Every eclipſe, whether of the ſun or moon, is viſible in ſome places of the earth's ſurface, and inviſible in others. For the rational horizon of any place divides both the earth and heavens into two equal hemiſpheres, and no celeſtial object can be ſeen but when it is above the ſpectator's horizon; therefore an eclipſe which is viſible to the inhabitants of one hemiſphere, muſt be inviſible to thoſe of the other; becauſe the object eclipſed is below the horizon of that other. For example, If a lunar eclipſe happens at any hour of the night between the riſing and ſetting of the ſun, it will be viſible there, and inviſible to the inhabitants of the other hemiſphere, which have the ſun above their horizon at that time; becauſe the ſun and moon are in oppoſite parts of the heavens at the time of a lunar eclipſe: and the ſame is true in eclipſes of the ſun, with reſpect to the ſun's being above or below the horizon. There is, however, a difference between the viſibility of ſolar and lunar eclipſes; for an eclipſe of the moon has the ſame appearance to all the inhabitants of that hemiſphere to which the moon is viſible at the time, owing, in part,

part, to the ſmall diſtance of the moon from the earth. But an eclipſe of the ſun may be viſible to ſome places, and inviſible to others, in the ſame hemiſphere of the earth; becauſe the moon's ſhadow is ſmall in compariſon of the earth's diſc, and its breadth (excluding the penumbra) is only about 180 miles, even in central eclipſes; and hence thoſe places which are conſiderably diſtant from the path of the ſhadow, may either have no eclipſe at all, or a very ſmall one, when places near the middle of the ſhadow have the greateſt poſſible.

PROB. XXXIV. *To calculate an Eclipſe of the Moon*

1. CALCULATE the true time of oppoſition by Prob. 32. and compute the longitude of the ſun, and the orbit longitude of the moon, for that time: if theſe differ 6 ſigns, the time of oppoſition is truly found; but if their difference be leſs or greater than 6 ſigns, mark the defect or exceſs, and find the moon's hourly motion from the ſun; then, as the hourly motion of the moon from the ſun is to one hour, ſo is the defect or exceſs to the interval; which being applied to the time formerly found, gives the true time of oppoſition. This operation muſt be repeated until the longitude of the ſun and the orbit longitude of the moon differ preciſely 6 ſigns.

2. Calculate the moon's latitude, horizontal parallax, and hourly motion, by the Tables, p. 53—60.; take alſo the ſun and moon's ſemidiameters out of the Tables, p. 18—58.

3. Add the ſun's horizontal parallax (which is 9 ſeconds) to the moon's for the time, and from the ſum ſubtract the ſun's ſemidiameter; the remainder is the ſemidiameter of the earth's ſhadow; to which add the moon's ſemidiameter, and the ſum is the ſemidiameter of moon and earth's ſhadow; from which ſubtract the moon's latitude, and the remainder is called *the parts deficient*. If theſe be leſs than the moon's diameter, the eclipſe will be partial; if they be equal to the moon's diameter, the eclipſe will be total without continuance; and if they be greater than the moon's diameter, the eclipſe will be total with continuance.

EXAM.

EXAM. 1. It is required to calculate the eclipse of the moon, which will happen in December 1797?

1. Calculate the time of opposition,

	D.	h.	m.	s.	Sun's anom. s.	°	′	″	Moon's anom. s.	°	′	″	☉'s dist. from ☊. s.	°	′	″
1797, new ☽ March	27	9	12	24	8	26	25	59	2	12	39	19	9	9	9	48
½ lunation -	— 14	18	22	2	—	14	33	10	— 6	12	54	30	—	15	20	7
Full moon March -	12	14	50	22	8	11	52	49	7	29	44	49	8	23	49	41
9 lunations -	+265	18	36	27	8	21	56	54	7	22	21	4	9	6	2	6
Full moon December	3	9	26	49	5	3	49	43	3	22	5	53	5	29	51	47
1 equation - -	—	1	52	47	— 3	21	23	13		—	42	40	arg. 4th equat.			
	3	7	34	2	1	12	26	30	3	21	23	13	Moon eclipsed.			
2 equations - -	+	8	53	8	arg. 3d equat.				arg. 2d equat.							
	3	16	27	10												
3 equations - -			—	3	11											
4 ditto - -				—	1											
Full moon December	3	16	23	58												

2. Calculate

2 Calculate the sun and moon's longitude for the time of full moon.

For the Sun's Longitude.

	Sun's Long.				Sun's anom.			
	S.	°	′	″	S.	°	′	″
1797 - -	9	10	37	33	6	1	8	17
December 3d -	11	2	9	47	11	2	8	46
16 h. - -			39	25			39	25
23 m. - -				57				57
58 s.				2				2
	8	13	27	44	5	3	57	27
Equation - -		—	51	45				
Sun's longitude -	8	12	35	59				

For the Moon's Longitude.

	Moon's m. Long.				Moon's anom.				Moon's ☊.			
	S.	°	′	″	S.	°	′	″	S.	°	′	″
1797 -	10	7	34	43	0	24	6	53	3	1	15	6
Decem. 3d -	4	0	26	45	2	22	54	4				
16h. -		8	47	3		8	42	36	—17	50	45	
23m. -			12	37			12	31		—2	7	
58s. -				32				32			—3	
	2	17	1	40	3	25	56	36	2	13	22	11
10 equations	+	1	25	1		+	9	44		+	4	3
	2	18	26	41	3	26	6	20	2	13	26	14
Equat. centre	—	5	45	57	+	1	25	1				
	2	12	40	44	3	27	31	21				
Variation -			+	6	arg. 11th.							
	2	12	40	50								
13th equation		—	1	13								
Moon's orb. lon.	2	12	39	37								
Sun's long.	8	12	35	59								
Paſt oppoſition			3	38								

Arguments.

	Arguments.				Equations.				
					+			−	
	S.	°	′	″	°	′	″	′	″
1	5	3	57	27	0	5	0		
2	5	12	48	49				0	17
3	7	4	53	55	0	0	43		
4	4	4	47	58	0	0	47		
5	8	12	54	46	1	17	15		
6	1	16	52	13	0	1	30		
7	3	8	57	19	0	0	46		
8	10	21	59	9				0	26
9	2	8	29	5				0	19
10	6	0	46	12	0	0	2		
12	6	0	4	45	+1	26	3	−1	2
13	8	0	57	51	−0	1	2		
14	11	29	9	29					
					+1	25	1		

	′	″
Moon's hourly motion -	35	18
Sun's ditto - - -	2	32
Hourly motion ☽ *à* ☉ - -	32	46

	L. L.
As hourly motion ☽ *à* ☉ 32′ 46″	2627
To one hour or 60m.	0
So is 3′ 38″ - -	12178
To 6m. 39s. - -	9551

	D.	h.	m.	s.
Former time December -	3	16	23	58
Interval ſubtract - -			− 6	39
Time of full moon -	3	16	17	19

	S.	°	′	″
Sun's longitude	8	12	35	43
Moon's ditto -	2	12	35	43
Reduction -			+	12

For

For the Moon's Latitude.

	Arguments.					
		S.	°	′	″	′ ″
1		11	29	13	23	— 4 11
2		0	0	53	23	+ 8
3		6	25	15	56	+ 6
4		2	29	19	20	— 25
5		11	3	22	44	— 7
	Moon's lat. S.					— 4 29

For the Moon's Horizontal Parallax.

	Arguments.					
		S.	°	′	″	′ ″
1		8	12	54	46	+ 0 11
2		3	27	31	21	+58 32
3		6	0	4	45	+ 0 27

Equatorial parallax -	59 10
Reduction - -	— 9
Horizontal parallax -	59 1

For the time of Reduction.

	L. L.
As Moon's hourly motion *à* ☉ 32′ 46″	2627
To 1h. or 60m.	0
So is reduction 12″	24771
To time of reduction + 22″.	22144

	′ ″
Sun's ſemidiameter -	16 17
Moon's ſemidiameter -	16 8

Angle of the moon's path with the ecliptic 5° 40′, Tab. p. 61.

Note: In eclipſes, the diſc of the ſun or moon is ſuppoſed to be divided into twelve equal parts called *digits*, and each of

of these again divided into 60 equal parts or minutes. The magnitude of an eclipse is estimated by the number of digits.

Calculation of the Eclipse.

	′	″
Moon's horizontal parallax -	59	1
Sun's ditto - - -	+ 9	
Sum - - -	59	10
Sun's semidiameter subtract -	— 16	17
Semidiameter of the earth's shadow	42	53
Moon's semidiameter add -	+ 16	8
Semid. of the moon and earth's shadow	59	1
Moon's latitude subtract -	— 4	29
Remains the parts deficient -	54	32

The eclipse will be total.

For the Digits Eclipsed.

	L. L.
As moon's semidiameter 16′ 8″	5704
To 6 digits	10000
So parts deficient 54′ 32″	415
To digits eclipsed 20° 16′	4711

	D.	h.	m.	s.
Mean time of orbit opposition Dec.	3	16	17	19
Time of reduction add and subtract			∓	22
Middle of the eclipse -	3	16	17	41
Ecliptic opposition -	3	16	16	57
To each of these add the equat. of time			+ 9	22
Appar. time of the middle of the ecl.	3	16	27	3
——— of ecliptic opposition	3	16	26	19

To find the Scruples of Incidence, or that part of the Moon's Path which she passes over between the beginning and middle of the Eclipse.

Reduce the sum of the semidiameters of the moon and earth's shadow to seconds, and also the moon's latitude; find their sum and difference; and to the logarithm of their sum add the logarithm of their difference, and divide the sum by 2, the quotient is the logarithm of the scruples of incidence in seconds.

In this example the semidiameter of the moon and earth's

	′ ″	″	Logarithms.
shadow is -	59 1 =	3541	
Moon's latitude	4 29 =	269	
Sum -		3810	3.5809450
Difference		3272	3.5148133
			2)7.0957583
Scruples of incidence or 58′ 50″.		3530	3.5478791

For the time of half duration.

	′ ″		L. L.
As hourly mo. ☽ from ☉ =	32 46		2627
To 1 hour or 60 minutes			0
So scruples of incidence	58 50	(29′ 25″)	3096
		h. m. s.	
To time of half duration	1 h. 47 m. 42 s	(0 53 51)	469
		2	
		1 47 42	

Because the terms of this proportion are such, that the fourth term comes out too great for the Table of logistical logarithms, take half of the third term; and then double the fourth term for the answer.

Apparent

	D.	h.	m.	s.
Apparent time of the middle of the eclipſe	3	16	27	3
Time of half duration, ſubtract and add	=	1	47	42
Beginning -	3	14	39	21
End - -	3	18	14	45

In total eclipſes of the moon, ſhe continues ſome time in total darkneſs; to calculate this time, it is neceſſary to find the half length of that part of the moon's path which lies wholly within the earth's ſhadow, which ſome call the *ſcruples of total darkneſs*. The operation is performed thus:

Subtract the moon's ſemidiameter from that of the earth's ſhadow; reduce the remainder, and alſo the moon's latitude, to ſeconds; then find their ſum and difference, and take the half ſum of the logarithms of the ſum and difference, and the number anſwering is the ſcruples of total darkneſs.

In this example,

	′	″
The ſemidiameter of the earth's ſhadow is	42	53
The moon's diameter - -	— 16	8
	26	45

	′	″	″	
The difference is	26	45	= 1605	
Moon's latitude	4	29	= 269	Logarithms.
Sum -			1874	3.2727696
Difference			1336	3.1258065
				2)6.3985761
Scruples			1584	3.1992880
or 26′ 24″				

For the time of half duration of total darkneſs.

	′	″	L. L.
As hourly motion of moon from ſun =	32	46	2627
To one hour or 60 minutes			0
So are ſcruples - -	26	24	3565
To time of half duration 48m. 21s.			938

Apparent

	D.	h.	m.	s.
Apparent time of the middle of the eclipſe	3	16	27	3
Half duration of total darkneſs ſubt. and add		∓	48	21
Beginning of total darkneſs - - -	3	15	38	42
End of ditto - - - -	3	17	15	23

From the calculation it appears, that the moon will be eclipſed at London 1797, Dec. 3d.

	Appar. time. h.	m.
Beginning of the eclipſe - -	14	39
Beginning of total darkneſs -	15	38
Ecliptic oppoſition - -	16	26
Middle of the eclipſe - -	16	27
End of total darkneſs - -	17	15
End of the eclipſe - -	18	14

Digits eclipſed 20° 16′ from S. ſide of earth's ſhadow.
Duration of the eclipſe 3 h. 35 m.
Duration of total darkneſs 1 h. 36 m.

To deſcribe a figure repreſenting the Eclipſe. Fig. 1.

1. Draw the ſtraight line AB for part of the ecliptic, in which take any point C, and draw CD at right angles to AB, for the axis of the ecliptic; which is drawn downwards, becauſe the moon's latitude at the beginning and middle of the eclipſe is ſouth.

2. Take the ſemidiameter of the moon and earth's ſhadow, 59′ 1″, from any ſcale, and with it, as a radius, deſcribe the circle ADB; the moon's centre is in one point of the circumference of this circle at the beginning, and, in the oppoſite point of it, at the end of a total eclipſe.

3. Take the ſemidiameter of the earth's ſhadow, 42′ 53″, from the ſame ſcale, and with it, from the centre C, deſcribe the circle KLM, to repreſent the earth's ſhadow.

4. Make

4. Make CD the radius of a line of chords on the ſector, and from it take the angle of the moon's path with the ecliptic 5° 40′, and ſet it from D to E towards the left hand (becauſe the moon's latitude is ſouth aſcending northward), and draw the line CE for the axis of the moon's orbit.

5. Take the moon's latitude 4′ 29″ from the ſcale, which ſet from C to F on the line CE; and through F draw the ſtraight line PN at right angles to CE; then the points N, F, and P, are the places of the moon's centre at the beginning, middle, and end of the eclipſe. Take the moon's ſemidiameter from the ſcale, and with it deſcribe circles from the centres N, F, and P. Theſe ſhall repreſent the moon at theſe points.

To mark the Hours on the Moon's path.

The middle of the eclipſe is December 3d 16h. 27m. 3s. which, in civil reckoning, is 4h. 27m. in the morning of December 4th, marked on the moon's path by the point F. Now, for the place of four hours, ſay,

As one hour
Is to the moon's hourly motion from the ſun 32′ 46″;
So is 27m. 3s.
To 14′ 46″ the diſtance of 4h. from F.

Take 14′ 46″ from the ſcale, and ſet it from F towards the right hand for the place of 4 hours; then take the moon's hourly motion from the ſun 32′ 46″, and ſet it on the moon's path from 4 to 3, and to 5, and alſo from 5 to 6, and the hours are marked. Divide each of the hour diſtances into ſix equal parts, and the place of the moon's centre will be known at every 10 minutes.

Exam. 2. Calculation of an eclipſe of the moon which will happen 1802, Sept. 11th.

Mean time of orbit oppoſition, Sept. 11d. 10h. 40m. At that time ſun's longitude 5s 18° 25′ 16″; moon's longitude

tude 11s. 18° 25′ 26″, latitude, north, 37′ 6″ ascending. Reduction — 1′ 40″, time of reduction 2m. 48s.

	′	″
Moon's hourly motion - -	38	4
Sun's ditto - - -	— 2	26
Moon's hourly motion from sun -	35	38

	°	′	″
Moon's semidiameter - - -	0	16	43
Sun's ditto - - - -	0	15	57
Moon's horizontal parallax - -	0	61	17
Angle of the moon's path with the ecliptic is -	5	38	0

Calculation of the Eclipse.

	′	″
Moon's horizontal parallax - -	61	17
Sun's ditto - - - -	+	9
Sum - - - -	61	26
Sun's semidiameter subtract -	— 15	57
Semidiameter of earth's shadow -	45	29
Moon's semidiameter, add - -	+ 16	43
Semidiameter of moon and earth's shadow -	62	12
Moon's latitude, subtract - -	— 37	6
Parts deficient - - -	25	6

For the digits eclipsed.

	°	′	″	L. L.
As moon's semidiameter -	0	16	43	5550
To 6 digits - - -				10000
So parts deficient -	0	25	6	3785
To digits - - -	9	0	0	8235

Mean

	D.	h.	m.	s.
Mean time of orbit oppoſition -	11	10	40	0
Time of reduction, ſubtract and add -		∓	2	48
Middle of the eclipſe -	11	10	37	12
Ecliptic oppoſition - -	11	10	42	48
Equation of time add to each -		+	3	31
Apparent middle of the eclipſe -	11	10	40	43
——— ecliptic oppoſition -	11	10	46	19

For the ſcruples of incidence.

	′	″	″	
Semid. of the ☽ and ⊖'s ſhadow	62	12	= 3732	
Moon's latitude - -	37	6	= 2226	
			———	Logarithms.
Sum - - - - -			5958	3.7751005
Difference - - - -			1506	3.1778250
				2)6.9529255
Scruples - - -			2995	3.4764627
Or - - - -			49′ 45″	

For the time of half duration.

	′	″	L. L.
As moon's hourly motion from ſun	35	38	2263
To 1 hour or 60m. - -			0
So $\frac{1}{5}$ ſcruples of incid. -	9	59	7789
To $\frac{1}{5}$ of half duration -	16	48	5526
		5	
Half duration -	1h.	24m.	0s.

	D.	h.	m.	s.
Apparent middle of the eclipſe	11	10	40	43
Time of half duration, ſubt. and add	∓	1	24	0
Beginning - -	11	9	16	43
End - - -	11	12	4	43

1802,

1802, September 11th, the moon is eclipſed.

	Appar. time.
	h. m.
Beginning - - - - -	9 16
Middle - - - - - -	10 40
Ecliptic oppoſition - - -	10 46
End - - - - -	12 4

Duration 2 hours 48 minutes. Digits eclipſed 9°

To deſcribe the Figure repreſenting the Eclipſe, Fig. 2.

This is done in the ſame manner as the former; only, becauſe the moon's latitude is north, the ſemicircles ADB and KLM muſt be above the ſtraight line AB; and becauſe the moon's latitude is aſcending northward, the angle of her path with the ecliptic 5° 38′ muſt be ſet from D to E towards the right hand. Draw CE for the axis of the moon's orbit, and thereon ſet the moon's latitude 37′ 6″ from C to F; and through F draw the ſtraight line NP at right angles to CE; and then the points N, F, and P, are the places of the moon's centre at the beginning, middle, and end of the eclipſe, as in the former example.

Take the moon's ſemidiameter 16′ 43″ from the ſcale, and with it, for a radius, deſcribe circles on the centres N, F, and P, which will repreſent the moon's diſc when ſhe is at theſe points; and then place the hours on the moon's path as directed in the former example.

Eclipses of the SUN.

Before proceeding to Solar Eclipſes, it will be proper to premiſe ſome things for explaining the terms uſed in the graphical delineation of them.

Although the earth is nearly a globe, yet when it is viewed from a very diſtant point, ſuch as the centre of the ſun, it will appear as a flat round ſurface, like the moon, to us; and this appearance is called *the earth's diſc*.

By

By the continual rotation of the earth round its axis every point on its ſurface deſcribes a circle parallel to the equator; and the circle deſcribed by any point or place is called *the path of the vertex of that place.*

The repreſentations of the paths of places on the earth's diſc are not always of the ſame form, but differ with the ſun's longitude; for when the ſun is in either of the equinoctial points, the paths of all places are repreſented by ſtraight lines; and when the ſun is in any other point of the ecliptic, they are repreſented by ellipſes, more or leſs eccentric according as the ſun is nearer to, or farther from, the equinoctial circle.

In deſcribing theſe paths on the earth's diſc, reſpect muſt be had to the poſition of the axes of the earth and ecliptic at the time.

When the ſun is in any of the aſcending ſigns ♑, ♒, ♓, ♈, ♉, ♊, the earth's axis lies to the right hand of the axis of the ecliptic; but when he is in any of the deſcending ſigns ♋, ♌, ♍, ♎, ♏, ♐, the earth's axis lies to the left hand. When the ſun is in either of the ſolſtitial points, the two axes coincide; and when he is in either of the equinoctial points, they form the greateſt angle.

When the ſun is in any of the northern ſigns, Aries, Taurus, &c. the north pole of the earth is in the upper or enlightened part of the earth's diſc; and when he is in any of the ſouthern ſigns, Libra, Scorpio, &c. the north pole of the earth is in the under or obſcure part of the diſc.

The tranſverſe diameter of any path is always at right angles to the earth's axis, and the conjugate diameter coincides with or is a part of it.

PROB. XXXV. *The Latitude of a Place, the Time of the Year, and the Sun's Longitude, being given to deſcribe the Earth's Diſc, and the Path of that Place thereon.*

EXAM. It is required to deſcribe the earth's diſc, and the

path of a place in latitude 51° 32′ N. 1803, Auguſt 17th, at 8 h. 19 m. in the morning, apparent time? Fig. 3d.

Sun's longitude 4 s. 23° 24′ 45″, diſtance from the ſolſtice 53° 24′ 45′; declination N. 13° 43′ 43″.

Draw the ſtraight line AB to repreſent a part of the ecliptic, and let C be the point therein, which is oppoſite to the ſun at the time: from C draw CH at right angles to AB, and CH is the axis of the ecliptic, and H its pole.

From the centre C deſcribe the ſemicircle AHB to repreſent the northern half of the earth's diſc. Make CA or CB the radius of the line of chords on the ſector, and take the chord of $23\frac{1}{2}$ degrees, which ſet from H both ways to *f* and *g*, and draw the ſtraight line *f*V*g*; the north pole of the earth is always in this line.

Make *f*V the radius of the line of ſines on the ſector, and take the ſine of 53° 24′ 45″, the ſun's diſtance from the ſolſtice, which ſet off from V to P towards the left hand, becauſe the ſun is in the ſign Virgo, and draw the ſtraight line CP*h* for the earth's axis; then P is the north pole of the earth. Or the angle contained between the earth's axis and that of the ecliptic may be found more accurately by calculation, thus:

		°	′
As radius - - -	S.	90	0 10.
Is to the ſine of the ſun's diſt. from the ſolſtice	53	25	9.9047106
So is the tan. of the diſtance of the poles	23	28	9.6376106
To the tan. of the angle contained by the axes	19	13	9.5423212

Now ſet off the chord of 19° 13′ from H to *h*, and join CH, which will cut *f g* in P, the place of the north pole.

Make CA the radius of the line of chords on the ſector; take the chord of 38° 28′, the complement of the latitude, and ſet it off from *h*, both ways, to *e* and *n*, where make marks. Again, take the chord of the ſun's declination 13° 43′ 43″ from the ſector, and ſet it off from the points *e* and *n*, both

both ways, to D and F, and to M and G; then draw the lines DM, FG, cutting CP in 12 and 12; and the line 12 K 12 is the conjugate axis of the ellipſe, which biſect in K, and through K draw the line 6 K 6 at right angles to CP.

Make CA the radius of the line of ſines on the ſector, and take the ſine of the co-latitude 38° 28′, and ſet it off from K, both ways, to 6 and 6. Theſe hours fall on the circumference of the diſc, when the ſun is in either of the equinoctial points; but at all other times they fall within it. The line 6 K 6 is the tranverſe axis of the ellipſe.

Make K 6 the radius of the line of ſines on the ſector, and from it take the ſines of 15°, 30°, 45°, 60°, and 75°, and ſet them off from K, both ways, towards 6 and 6; and through theſe points draw lines parallel to CP. Again, make K 12 the radius of the line of ſines on the ſector, and take from it the ſines of 75°, 60°, 45°, 30°, and 15°, and ſet them off on the parallels, beginning with that next to 12 K 12; and through theſe points draw a curve line, which will be the path of the given place. Mark the hours on the path as per Figure, and divide them into halves, quarters, and ſmaller parts, at pleaſure.

The 12 next to P marks midnight, when the ſun's declination is north; and that part of the path is below the diſc: but the other 12 between K and C is noon or mid-day. The path touches the circumference of the diſc a little before 5, which is the time of ſun-riſing; and again a little after 7, the time of ſun-ſetting.

In north latitude, when the ſun's declination is ſouth, the 12 neareſt to P is mid-day, and the other is midnight.

In the ſame manner, the parallel of latitude, or path of any place, may be deſcribed on the earth's diſc for any given time, and is uſed in repreſenting the appearance of an eclipſe of the ſun.

PROB. XXXVI. *To Calculate an Eclipse of the Sun.*

1. CALCULATE the time of mean conjunction, with the sun's distance from the moon's node, and thereby find if an eclipse will happen; and if it do, calculate the true time of conjunction, and the sun and moon's longitudes at that time.

2. Calculate the moon's latitude, horizontal parallax, horary motion, semidiameter, and angle of her path with the ecliptic.

3. Calculate the sun's declination, hourly motion, and his distance from the solstice.

Having found these necessary requisites, write them down in order to be ready for use.

EXAM. The sun will be eclipsed in August 1803.

The time of mean conjunction is Aug. 17d. 7h. 12m. 24s.

Sun's mean dist. from the moon's node 6s. 2° 8′ 8″.

And the true conjunction is Aug. 16d. 20h. 30m. 34s. mean time.

		S.	°	′	″
The sun's longitude then	-	4	23	25	3
The moon's orbit longitude	-	4	23	28	49
Past conjunction	- -	0	0	3	46

Sun's mean anomaly 1s. 15° 8′ 15″.

		′	″
Moon's hourly motion	- -	30	57
Sun's ditto subtract	- -	2	24
Moon's hourly motion from sun	-	28	33

	L.	L.
As moon's hourly motion *à* ☉ 28′ 33″		3225
To 1 hour or 60 minutes		0
So is difference of longitudes 3′ 46″		12022
To interval — 7m. 54s.		8796

From

	D.	h.	m.	s.
From the time formerly found -	16	20	30	34
Subtract the interval -			— 7	54
Correct time of conjunction -	16	20	22	40
Equation of time - -			— 3	48
Apparent time of conjunction	16	20	18	54

or 8h. 18m. 54s. in the morning of Aug. 17th.

For the Sun and Moon's places at the corrected time of Conjunction.

m. ′ ″ m. s. ″

As 60 : 2 24 : : 7 54 : 18 to be ſubtracted from ☉'s long.

60 : 30 57 : : 7 54 : 4′ 4″ to be ſubt. from the ☽'s long.

	s.	°	′	″
And then the ſun's longitude is	4	23	24	45
The moon's ditto - -	4	23	24	45

	°	′	″
2. The moon's horizontal parallax, or ſemidiameter of the earth's diſc -	0	55	9
3. Sun's diſtance from the neareſt ſolſtice -	53	24	45
4. Sun's declination north - -	13	43	43
5. Angle of the moon's path with the ecliptic	5	43	0
6. The moon's latitude ſouth deſcending -	0	0	46
7. The moon's hourly motion from the ſun	0	28	33
8. The ſun's ſemidiameter 15′ 52″			
9. The moon's ſemidiameter 15 4			
10. The ſemidiameter of the penumbra, or ſum of the ſemidiameters of ſun and moon	0	30	56

In this example the ſun's diſtance from the neareſt ſolſtice is found by ſubtracting 3 ſigns from his longitude. The angle of the moon's path with the ecliptic is taken out of the Table, p. 61.

The method of finding the other numbers has been taught formerly.

PROB. XXXVII. *To deſcribe a Figure repreſenting the Eclipſe, and to find its magnitude, beginning, middle, and end, at London.* Fig. 3.

DRAW the ſtraight line AB to repreſent a part of the ecliptic: take the ſemidiameter of the earth's diſc from a ſcale, and with it as radius deſcribe the ſemicircle AHB for the northern half of the earth's diſc, and thereon deſcribe the path of London, as has been taught in the preceding problem.

Make the ſemidiameter of the diſc CA the radius of the line of chords on the ſector, and take the chord of 5° 43′, the angle of the moon's path, which ſet off on the circumference of the diſc, from H towards the right hand, to M, becauſe the moon's latitude is ſouth deſcending, and draw CM for the axis of the moon's path.

Set off the moon's latitude 46″ ſouth on MC, produced below AB to X; and through X, at right angles to MC, draw the line of the moon's path, which cuts AB on the left hand of X. The point X is the time of conjunction by the Tables.

To find the place of 8 hours on the moon's path.

	L. L.
As 1 hour or 60 minutes	0
To the ☽'s hourly motion from the ☉ 28′ 33″	3225
So is the time of conjunct. after 8h. 18m. 52s.	5025
To the diſtance of 8 hours from X 8′ 58″	8250

Take 8′ 58″ from the ſcale, and ſet it off from X towards the left hand for the place of 8 hours on the moon's path.

Take alſo from the ſcale 28′ 33″, the moon's hourly motion from the ſun, and ſet it off both ways from 8 to 9 and 7, as alſo from 7 to 6, &c. and the places of the hours on the moon's path will be known. Divide each hour diſtance into 12 equal parts by dots, and the place of the moon's centre,

centre, or rather the centre of the penumbra, will be known at every 5 minutes during the eclipſe.

To find the middle of the Eclipſe.

Apply one ſide of a ſquare to the path of the moon or penumbra's centre, and move it backward and forward until the other ſide of the ſquare cuts the ſame hour and minute on the path of London and of the penumbra's centre, which in this example is at *y* and *u* in 6 hours 32 minutes, the middle of the eclipſe.

Take the ſun's ſemidiameter 15′ 52″ from the ſcale, and with it deſcribe a circle about the point *y* for the ſun's diſc: then take the moon's ſemidiameter 15′ 4″ from the ſcale, and with it deſcribe a circle about the point *u* for the moon's diſc at the middle of the eclipſe. The part of the ſun's diſc cut off by the moon's is the magnitude of the eclipſe as it will appear at London. In this example it is about $3\frac{1}{2}$ digits.

Laſtly, take the ſemidiameter of the penumbra 30′ 56″ from the ſcale; and ſetting one foot of the compaſſes on the moon's path, and the other on the path of London, towards the left hand, carry that extent backwards and forwards until both points fall on the ſame hour and minute in each path, and that is the beginning of the eclipſe at London. With the ſame extent of the compaſſes, and one foot on each path, carry them backwards and forwards towards the right hand; and where both points fall on the ſame time, that will be the end of the eclipſe at London. Theſe trials give,

	h.	m.
The beginning of the eclipſe at -	5	50
The middle - - -	6	32
The end - - -	7	30

Duration 1h. 40m. Digits 3° 30′.

EXPLA-

EXPLANATION OF THE TABLES.

THE Table containing the latitudes and longitudes of ſome cities and places is collected from the beſt obſervations, and is equally uſeful in geography and aſtronomy; for it is by the latitude and longitude of any point or place on the earth's ſurface that its poſition and diſtance from any other point on the ſame ſurface is determined, as alſo the poſition of the ſtars for any given time. The difference of time between the meridians of different places affords an eaſy rule for making aſtronomical tables, calculated for any place, anſwer univerſally for all places whoſe longitudes are known.

TABLES of the Mean Motions of Celeſtial Objects.

THE idea that the ſun, moon, and ſtars, performed all their motions in circles, was perhaps one of the firſt which men received concerning theſe very diſtant bodies. The regular returns of day and night, of the ſeaſons of the year, and of almoſt all things in the viſible world, would ſerve to confirm it: and although it is well known that the orbits of the planets are not perfect circles, it is equally known that they differ very little from circles; and therefore modern aſtronomers retain the idea, and form tables of the motions of the planets, as if their orbits were circles, and their motions

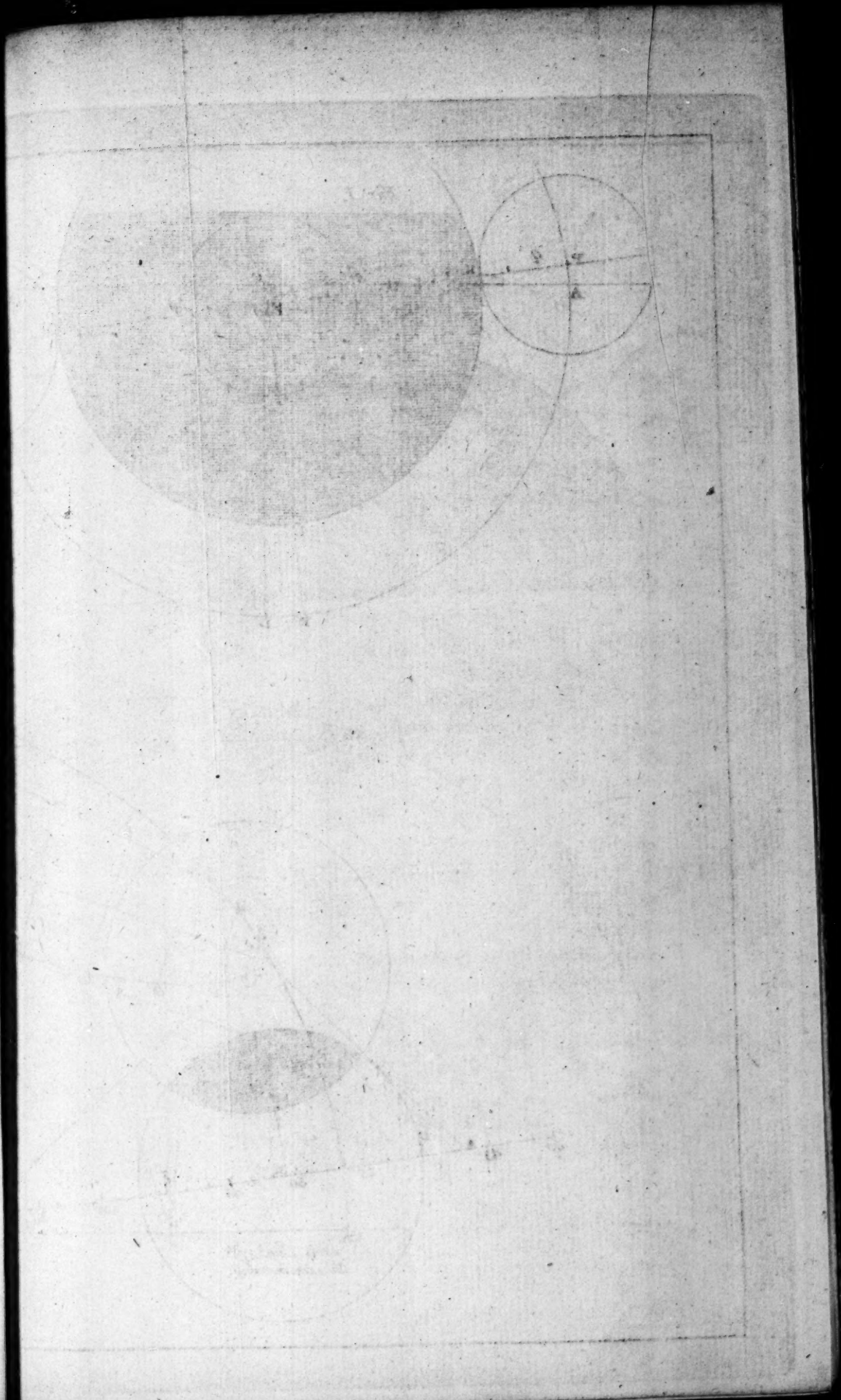
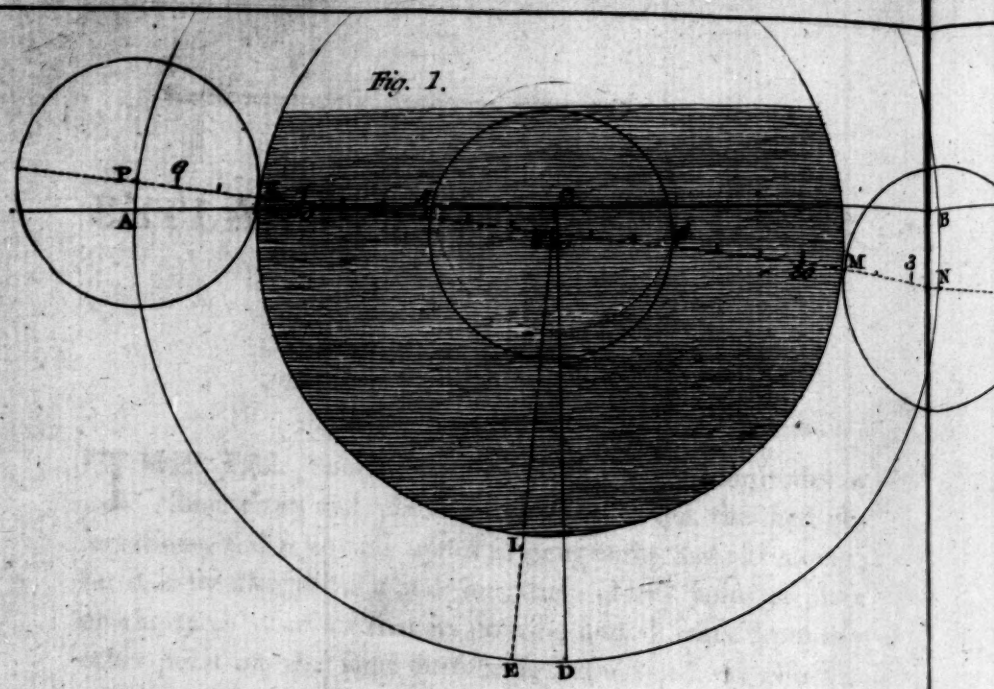
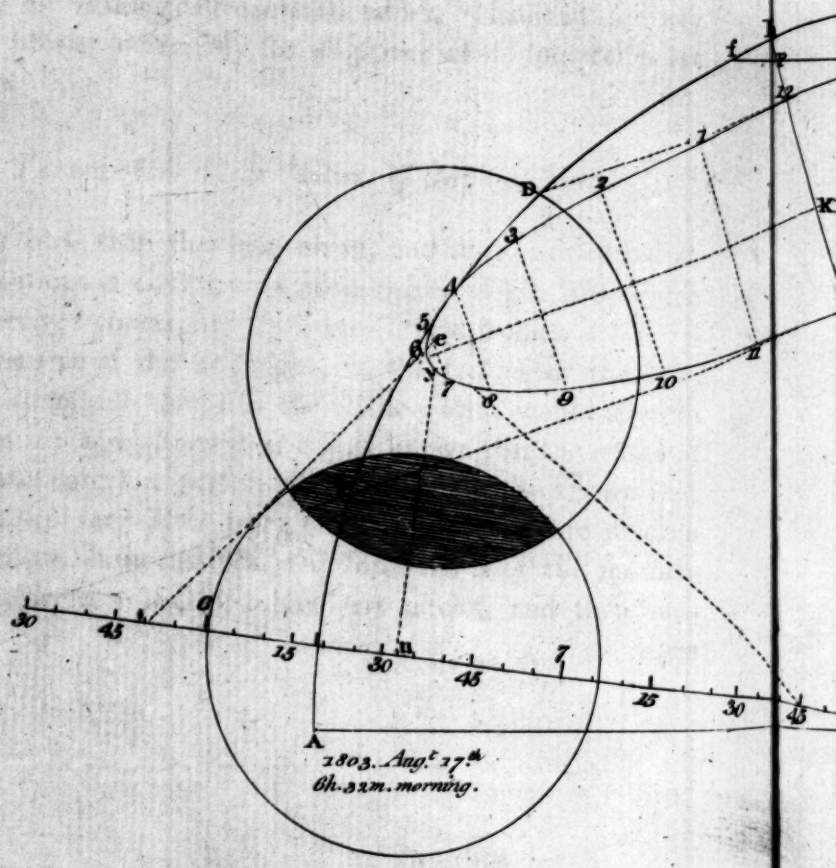


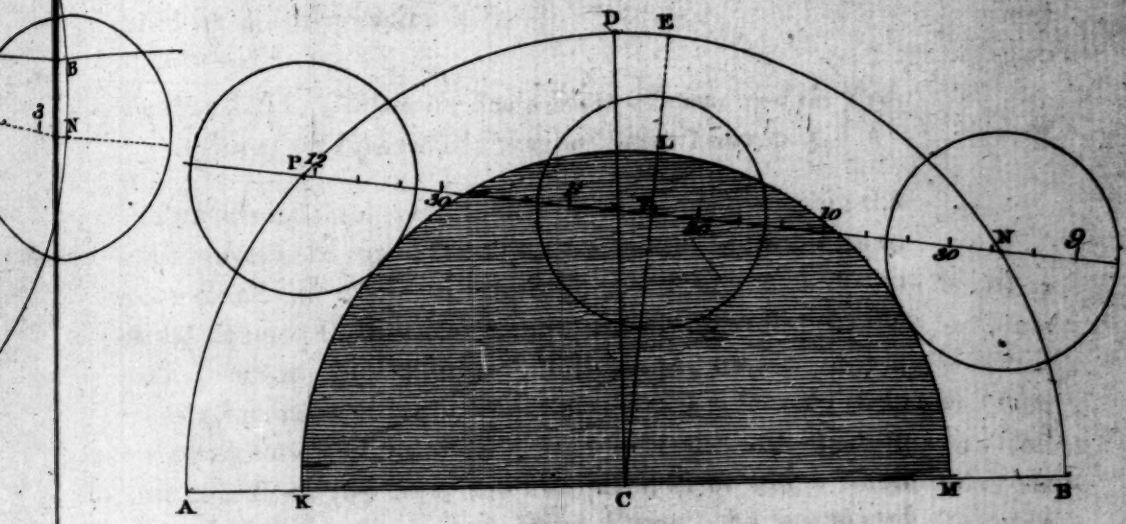
Fig. 1.





1803. Aug.t 17th
0h. 32m. morning.

Fig. 2.



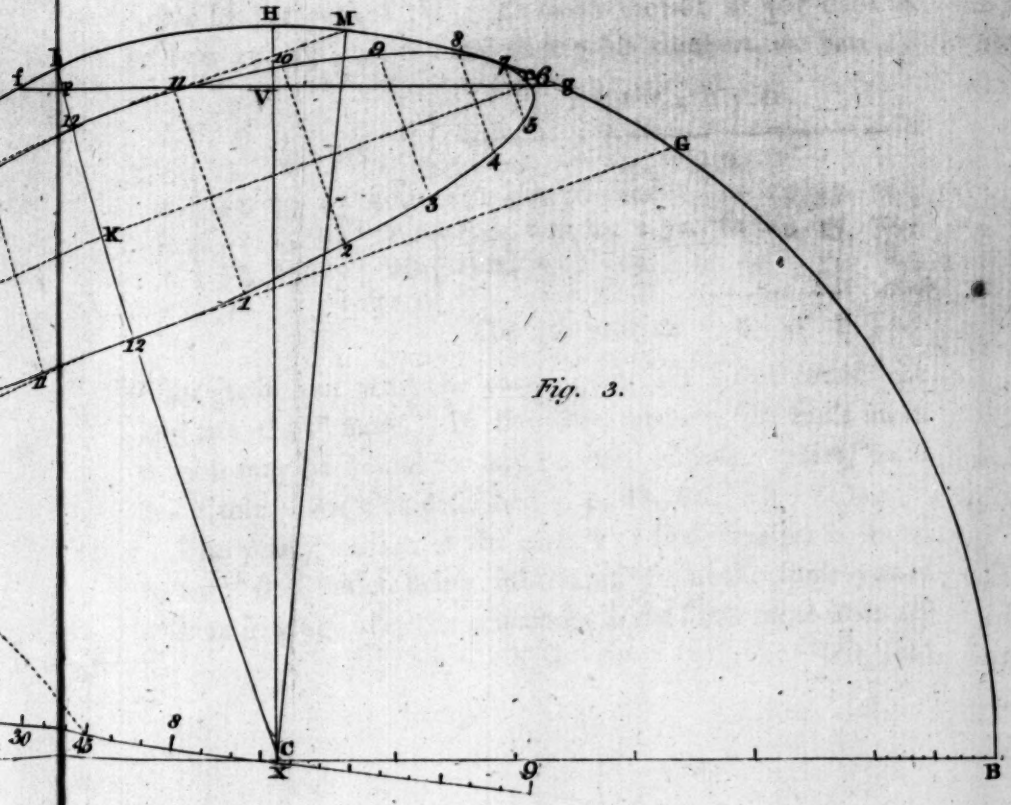
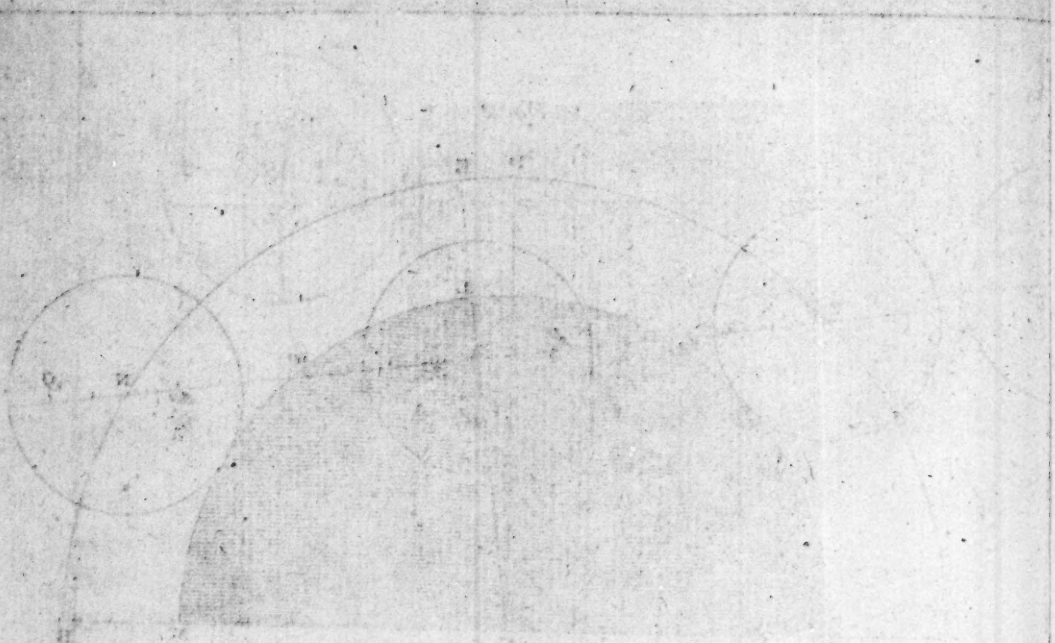


Fig. 3.



tions always uniform, passing over equal spaces in equal times: Such are called *Tables of Mean Motion;* and the longitude of a planet computed from such tables for any given time is called its *mean longitude.*

TABLES I. II. *Contain the Sun's Mean Motion, and the Precession of the Equinoctial Points in Julian Years,* p. 5.

THE astronomical year is that space of time wherein the earth moves once round the sun, or wherein the sun seems to move round the whole ecliptic from any point, such as the vernal equinox to the same again; which, according to the most accurate observations, consists of 365 natural days 5 hours 48 minutes 54¼th seconds; but in civil reckoning there are two kinds of years, common and bissextile. A common year consists of 365 days, and the bissextile of 366. These are called *Julian years,* from Julius Cæsar, who introduced this method of computation.

Mr Mayer makes the sun's mean motion in 365 days to be 11s. 29° 45′ 40″.7. Admitting his numbers, we have,

Year.	S.	°	′	″
1	11	29	45	40.7
2	11	29	31	21.4
3	11	29	17	2.1
4	0	0	1	51.1

For the 4th year.

	S.	°	′	″
To the 3d year	11	29	17	2.1
Add mo. for 1 yr.	11	29	45	40.7
And for 1 day			59	8.3
The 4th year =	0	0	1	51.1

That is, in four years the earth goes four times round the sun, and 1′ 51″ more. In the same manner, the sun's mean motion may be found for any number of Julian years, as in the Table. See this described in p. 88, 89.

The yearly motion of the earth's or sun's apogee is found to be 1′ 6″; which being subtracted from the sun's yearly motion in longitude, the remainder is the sun's mean anomaly

for 1 year; and for any number of years the mean anomaly is found in the ſame manner as the mean longitude.

It has been found by obſervation, that the equinoctial points move backward, contrary to the order of the ſigns, at the rate of 50″.3 yearly, called the *preceſſion of the equinoxes*; and multiplying 50″.3 by 2, 3, 4, 5, &c. the numbers in Table II. are found.

TABLE III. *Contains the Sun's Mean Longitude and Anomaly, with the Obliquity of the Ecliptic, for Years current of the Chriſtian Æra*, p. 6.

THE Table is compoſed in this manner: The mean longitude and anomaly of the ſun, with the obliquity of the ecliptic, are found for the noon of the laſt day of December 1760, which is accounted his mean longitude, &c. for the ſucceeding year 1761. To theſe numbers add the ſun's mean motions for 20 years, taken from Table I.; the ſums are the ſun's mean longitude and anomaly for 1781. To theſe add the mean motions for 10 years, and the mean longitude and anomaly for 1791 are known. And for the following years add the ſun's mean motions in one year to his mean longitude and anomaly for the preceding year continually; remembering to add the motion of 1 day more for every biſſextile year, until the number of years which the Table is to contain are completed.

The annual differences of the obliquity of the ecliptic are very ſmall, and not always regular. It appears by the Table that the difference is only about 25″ in 60 years; therefore the obliquity of the ecliptic may be ſtated at 23° 28′ during the next 50 years without ſenſible error.

When the ſun's mean longitude and anomaly are wanted for any year which is not in the Table, take the mean motions for the intermediate years from Table I. and if the year is before 1761 ſubtract them; if after it, add them to the numbers

numbers for 1761, and the ſum or remainder will be the mean longitude and anomaly required.

In theſe additions 12 ſigns are to be rejected as often as they occur; and in the ſubtractions 12 ſigns muſt be borrowed when neceſſary.

TABLE IV. p. 7—12. Contains the ſun's mean motions for the days of the year, diſtributed into 12 kalendar months. At the noon of January 1ſt there is one aſtronomical day paſt, becauſe it began at the noon of December 31ſt; and therefore the ſun's mean motions in one day are put down. Theſe being multiplied by 2, 3, 4, 5, &c. (allowance being made for the fractions in one day's motion), the products are the numbers of the Table; remembering to place them properly, *viz.* the motions for 31 days at the laſt day of January; for 32 days at the 1ſt day of February; and ſo on until the 31ſt of December.

TABLE V. Contains the ſun's mean motions for hours, minutes, and ſeconds, which may be underſtood from what has been ſaid of his motions for days, p. 13.

TABLE VI. *Of the Mean Refractions.*

THE difference between the true and apparent altitude of any object in the heavens is called its *refraction:* the quantity of it agreeing to any altitude is found in the Table, and is to be taken out and ſubtracted from the apparent altitude, and the remainder is the true altitude.

TABLE VII. *Equations of the Sun's Centre*, p. 14.

THE ſun's mean and true longitudes differ more or leſs in every point of the earth's orbit except two, *viz.* the aphelion and perihelion; and theſe differences are called *equations*

of

of the ſun's centre. One cauſe of the difference is, that the earth's orbit is an ellipſe, in the periphery whereof the true longitude is reckoned from the vernal equinox, and the mean longitude is reckoned from the ſame point in the circumference of a circle, whoſe diameter is the greater axis of the ellipſe. The circle and ellipſe coincide only in the aphelion and perihelion; and therefore when the ſun or earth is in either of theſe points, the mean and true longitudes are the ſame, and there is no equation.

Another cauſe of the difference between the mean and true longitudes ariſes from the unequal motion of the earth in its orbit: for while the earth proceeds from its aphelion to its perihelion, its motion is continually accelerated; and from its perihelion to its aphelion, its motion is continually retarded; and this is true of every planet.

When the ſun appears in the earth's aphelion, his longitude is about 3s. 9°, and his anomaly is 0, becauſe it is reckoned from that point: and when he appears in the earth's perihelion, his longitude is nearly 9s. 9°, and his anomaly is 6 ſigns. In the firſt ſix ſigns of anomaly, the equation found in the Table is to be ſubtracted from the mean longitude; in the other ſix ſigns it is to be added, and the ſum or remainder is the true longitude.

TABLE VIII. *Contains the Logarithms of the Earth's Diſtances from the Sun*, p. 15, 16.

BECAUSE the earth's orbit is an ellipſe, and the ſun in one of its foci, the earth's diſtance from the ſun varies every moment: for it is greateſt in aphelion, and decreaſes as the earth proceeds from thence towards the perihelion, where it is leaſt. The ſeveral diſtances decreaſe in the firſt ſix ſigns of anomaly, and increaſe in the other ſix. When the anomaly 3 or 9 ſigns, the earth is at its mean diſtance from the ſun, expreſſed

expreſſed by 1000000. In all other points the diſtance is either greater or leſs than the mean.

The earth's diſtance from the ſun being calculated for every degree of anomaly, the logarithms of theſe diſtances are contained in the Table, and are of uſe in computing the longitudes of the other planets.

TABLE IX. *The Sun's Declination to every Degree of his Longitude*, p. 17.

AT the time of either equinox the ſun is in the equinoctial circle, but at all other times he appears at ſome diſtance from it, either north or ſouth; and this diſtance is called his *declination*.

At the vernal equinox the ſun has no declination; but from that point his declination increaſes northward, until he comes to the ſummer ſolſtice, where it is greateſt; and from thence it decreaſes until the ſun is at the autumnal equinox, when again it is nothing; and then changes its name from north to ſouth, and increaſes ſouthward to the winter ſolſtice, where again it is greateſt; and from thence it decreaſes until the ſun appears in the vernal equinox.

Thoſe points of the ecliptic, which are equally diſtant from the equinoxes or ſolſtices, being alſo equally diſtant from the equinoctial circle, have the ſame declination; and therefore the declination being calculated for every degree of the firſt quadrant of the ecliptic, anſwers for the whole; for the beginning of the ſign Taurus, of Virgo, of Scorpio, and of Piſces, are all at the ſame diſtance from the equinoctial circle, and conſequently theſe points have the ſame declination; only in the two firſt the declination is north, and in the two laſt it is ſouth: and the ſame is true of all other points of the ecliptic which are equally diſtant from the equinoctial or ſolſtitial points.

TABLE

TABLE X. *The Sun's Apparent Semidiameter and Hourly Motion.* p. 18.

WHEN the earth is in its aphelion, the ſun's diameter appears leaſt, and his apparent motion ſloweſt; his diameter at that time is only 31′ 34″, and his hourly motion 2′ 23″. While the ſun moves apparently from the aphelion to the perihelion, his diameter and hourly motion increaſe with his anomaly, and are greateſt in the perihelion; his diameter being then 32′ 38″, and his hourly motion 2′ 33″. The difference between the aphelion and perihelion diameter is 64″, and between the hourly motions 10″.

The Table contains the ſun's ſemidiameter and hourly motion to every 10° of mean anomaly; which, by taking proportional parts for the intermediate degrees, will ſerve to find them for any given anomaly. They are frequently of uſe in Aſtronomy, eſpecially in calculating eclipſes.

TABLE XI. Contains the equation of time for every degree of the ſun's longitude, p. 19—20; and by uſing proportion for the minutes and ſeconds, the equation may be found for any given longitude. For example, Let it be required to find the equation of time when the ſun's longitude is 6s. 10° 50′ 30″? *Anſ.* — 11m. 12s.

s.	°		m.	s.		°	s.	′	″	s.
6	10	gives	10	57	As	1	: 18	: : 50	30	: 15
6	11	——	11	15	Add		-		10	57
Diff.				18	True equation				11	12

TABLE XII. Contains the equation of time for the noon of every day in the year, p. 21, 22. This Table being calculated the 2d after leap year, the numbers in it are not preciſely true for every year; but the error is ſo ſmall that it may be neglected where great preciſion is not required: and it is con-

convenient to have the equation of time nearly true by inſpection.

TABLE XIII. *Reduction of the Ecliptic to the Equator; or for computing the Right Aſcenſion of any Point of the Ecliptic; and* vice verſa, p. 23, 24.

THE colures are the only meridians which divide both the equinoctial and ecliptic into equal parts; all the other meridians divide them unequally. And becauſe the longitude of any celeſtial object is reckoned on the ecliptic from the vernal equinox, in the order of the ſigns, and the right aſcenſion is reckoned on the equinoctial from the ſame point to the meridian, paſſing through the object, and theſe circles are inclined to each other in an angle of about $23\frac{1}{2}$ degrees; the longitude and right aſcenſion can never be the ſame, except when each of them is 0, 90, 180, or 270, degrees. They differ in every other point; and their differences are contained in the Table, which are calculated to every 30′ of longitude, and will ſerve for any point of the ecliptic by making proportion for the odd minutes.

In the firſt and third quadrants of the ecliptic the numbers in the Table are to be ſubtracted from the longitude, and in the ſecond and fourth to be added, for the right aſcenſion; which is indicated by their ſigns.

TABLES XIV and XV. *The Sun's Longitude and Right Aſcenſion every Day at Noon*, p. 25—28.

THE conveniency of having the ſun's longitude and right aſcenſion nearly true for the noon of every day in the year, inclined me to inſert theſe Tables. The reaſon why they could not be made accurate is, a common year of 365 days differs from the time wherein the ſun ſeems to move round the

the whole ecliptic by almoſt 6 hours, or a day in four years; which cauſes a difference in the ſun's longitude at noon on the ſame days of different years; and therefore to have made the Tables more perfect, each of them muſt have been calculated for four years, which would have taken up more room than was thought proper to beſtow. But although not perfect, they are not uſeleſs; for the right aſcenſion of any ſtar being ſubtracted from the ſun's, taken from the Table, the remainder will ſhow the time when that ſtar comes to the meridian, ſo near as to enable one to find the ſtar in the heavens, and know it again: and if the right aſcenſion of the moon be ſubtracted from the ſun's right aſcenſion, the remainder will ſhow the time when the moon comes to the meridian that day, within a few minutes of the truth. Theſe things are frequently of uſe in practical aſtronomy.

Tables of the Moon's Mean Motions, p. 29—43.

These Tables are made in the ſame manner as thoſe of the ſun or earth, the moon's period being known: but her motions are more in number than thoſe of the earth; for beſides her mean longitude and anomaly, the longitude of her node muſt be known, in order to calculate her place for any given time.

The earth is in one of the foci of the moon's orbit, and is the centre of her motion; for the moon revolves round the earth in the ſame manner as the earth moves round the ſun.

The moon's period, or the time wherein ſhe moves once round the earth, is 27 days 7 hours 43 minutes 5 ſeconds; and to find the moon's mean motion in a common year of 365 days, the proportion is,

As the moon's period 27 d. 7 h. 43 m. 5 s.
Is to her whole orbit or 360°;
So is a common year of 365 days
To 13 revolutions, and 4 s. 9° 23′ 5″.

The

The 13 revolutions are rejected, and 4s. 9° 23′ 5″ is taken for the moon's mean motion in 365 days.

For the Moon's Mean Motion in one Day.

As the moon's period 27d. 7h. 43m. 5s.
Is to the whole circle or 360°;
So is one day
To the moon's mean motion in 1 day 13° 10′ 35″.

Having the moon's mean motion in 1 year and 1 day, the Table of her mean longitudes for Julian years is made by multiplying the motion for 1 year by 2, 3, 4, &c. and to the 4th add the motion for 1 day, the products are the mean longitudes for these years: and by multiplying the motion for 1 year by the several numbers of years, and adding the motion in 1 day to every 4th or bissextile year, the Table may be made to any extent.

To calculate the Moon's Mean Anomaly.

The moon's apogee moves once round her whole orbit in 8 years 309 days 8 hours 20 minutes; or (adding 2 days for leap years) in 3231 days 8 hours 20 minutes. Then,

As 3231d. 8h. 20m.
Is to the whole circle or 360°;
So is a common year of 365 days
To the mo. of the ☽'s apogee in 1 year 40° 39′ 50″.

	S.	°	′	″
From the ☽'s m. mot. in lon. during 1 year	4	9	23	5
Subtract the motion of her apogee in ditto	—1	10	39	50
There remains the ☽'s mean anomaly in 1 year	2	28	43	15

To find the Moon's Mean Anomaly for one Day.

Divide the motion of her apogee in a year, viz. 40° 39′ 50″ by 365, and the quotient 6′ 41″ is the motion of the moon's apogee for 1 day.

	°	′	″
From the moon's motion in longitude for 1 day	13	10	35
Subtract the motion of her apogee for ditto		— 6	41
There remains the moon's mean anom. for 1 day	13	3	54

Having found the moon's mean anomaly for 1 year and 1 day, the ſeveral mean anomalies in the Table are found in the ſame manner as the longitudes, viz. by multiplying the mean anomaly for 1 year by 2, 3, 4, &c. and adding the motion for 1 day to every 4th or biſſextile year.

To find the Mean Motion of the Moon's Node.

The moon's node moves backward round her whole orbit in 18 years 224 days 5 hours; therefore, for its motion in one year,

As 18 years 224 days 5 hours
Is to the whole circle or 360°,
So is a year of 365 days
To the motion of the ☽'s node in 1 year 19° 19′ 43″.

For the motion of the moon's node in 1 day, divide 19° 19′ 43″ by 365, and the quotient, which is nearly 3′ 11″, is its motion for 1 day.

The motion of the moon's node for 1 year and 1 day being known, its motion for any number of years are found in the ſame manner as thoſe of mean longitude and anomaly, viz. by multiplying one year's motion by 2, 3, 4, &c. and adding the motion of a day to every fourth or biſſextile year.

TABLE II. *Containing the Moon's Mean Longitude and Anomaly, with the Longitude of her Node, for current Years,* p. 30.

To make the Table, find, either by calculation or a good obſervation, the moon's mean longitude and anomaly, with the

the longitude of her node, on the noon of the laſt day of December preceding the year, where the Table is to begin, which here is the year 1760, and theſe are the mean places for 1761, the firſt in our Table. For 1781, the next year in the Table, take the mean motions for 20 years from Table I. and add the longitude and anomaly to thoſe for 1761, but ſubtract the motion of the node; the reſults are the mean places for 1781: then take the mean motions for 10 years, and apply them in the ſame manner to the numbers for 1781, and the mean places for 1791 will be known.

For the following years the Table is carried on by the continual addition of the mean longitude and anomaly for 1 year, as alſo the motion for 1 day more every 4th or biſſextile year, and ſubtracting the motion of the node.

TABLE III. p. 31—42. contains the moon's mean motions for days. It begins with the mean motions for one day already found. Theſe being multiplied by every number of days from 1 to 365, place the products at the proper days of the ſeveral months, and the Table is made.

TABLE IV. *Contains the Moon's Mean Motions for Hours, Minutes, and Seconds*, p. 43.

THE numbers are found by dividing the mean motions for 1 day by 24, the quotients are the mean motions for an hour; and theſe again divided by 60, give the mean motions for 1 minute, &c. The motions for the different numbers of hours and minutes are found by multiplication.

The moon's motions are affected with many inequalities, and therefore many equations are neceſſary to reduce her mean longitude to the true, p. 44—52. The method of finding the arguments, of taking out the equations, and applying them, is deſcribed in Prob. XIII.

The Tables for finding the moon's latitude, parallax, diameter,

meter, hourly motion in longitude and latitude, at any given time, p. 53—60. are ſufficiently plain from their titles; and the method of applying them is deſcribed in Prob. XIV—XIX.

Tables for finding the Right Aſcenſion and Declination of the Moon; of any Planet or Fixed Star, whoſe Latitude does not exceed 6 Degrees, p. 62—69.

The longitude and latitude of the moon, or of any planet, being given, to find its right aſcenſion and declination, is a problem of conſiderable length when ſolved by ſpherical trigonometry. The Tables ſerve to ſhorten the operation; and the numbers in them being applied according to the directions given in Prob. XX. the right aſcenſion and declination are found with little trouble in compariſon of any other method.

The Tables, p. 23—24. contain the difference between the longitude and right aſcenſion of any point of the ecliptic; but the Tables, p. 62—67. contain the difference between the longitude and right aſcenſion of points at ſome diſtance from the ecliptic, whereby the right aſcenſion of any planet within 6° of the ecliptic may be found. The ſame is true of the Table, p. 17. compared with thoſe in p. 68—69.

Theſe Tables are of great uſe; for neither the time when a planet is on the meridian, nor of its riſing or ſetting, can be found without knowing its right aſcenſion and declination. See Prob. XXV.—XXIX.

Tables of the Mean Motion of the Moon from the Sun, p. 70, 71.

The moon's mean motion in a common year of 365 days

is

4s. 9° 23′ 5″, over and above 13 revolutions; and the ſun's apparent mean motion in the ſame time is 11s. 29° 45′ 40″.

		s.	°	′	″
From	-	4	9	23	5
Subtract	-	11	29	45	40
The remainder		4	9	37	25

is the moon's mean motion from the ſun in a common year.

In the ſame manner, the moon's mean motion from the ſun may be found for a day, an hour, or for any number or parts of theſe.

Having the moon's mean motion from the ſun in a year and a day, it may be found for any number of years by multiplication; remembering to add the motion for one day to every four years motion for leap year.

To make a Table of the moon's mean motion from the ſun for current years of the Chriſtian æra, ſubtract the ſun's mean longitude from the moon's for every year which the Table is to contain; and the remainders will be the numbers expreſſing the moon's mean motion from the ſun; as in the Table, p. 70.

The Table for months is made by ſubtracting the ſun's mean longitude from the moon's on the laſt day of the preceding month; and the remainder is the moon's mean motion from the ſun on the firſt day of the following month. The Tables for days, hours, minutes, and ſeconds, are made in the ſame manner; and the method of uſing theſe Tables is deſcribed in Prob. XXX.

Table of Mean New Moons in March, with the Mean Anomalies of the Sun and Moon; and the Sun's Mean Diſtance from the Moon's Node, p. 121, &c.

To make Table 1. Calculate the time of mean new moon in March, for the year with which the Table is to begin, by

by the rule, p. 199. or by any other method: Calculate alſo the ſun and moon's mean anomalies for that time, and the ſun's mean diſtance from the moon's node, from the Tables of mean motion, and write them down in order.

For the following years. If the new moon falls after the 11th day of March, add 12 lunations to the time for the former year; and if the next is a common year, ſubtract 365 days from the ſum; the remainder is the time of mean new moon in March the next year; but if the next be a leap year, ſubtract 366 days. If the mean new moon falls before the 11th of March, add 13 mean lunations, and ſubtract 365 or 366 days from the ſum, according as the next is a common or biſſextile year.

Calculate alſo the ſun and moon's mean anomalies, with the ſun's mean diſtance from the moon's node, for 12 or 13 lunations, and add them to thoſe of the former year; and the numbers for the ſecond year in the Table will be known. Proceed in the ſame manner for every ſucceeding year until the Table is completed.

TABLE II. *Contains* 13½ *Mean Lunations, with the Anomalies, and the Sun's Mean Diſtance from the Moon's Node.*

THE numbers are computed from the Tables of mean motion thus: Take the mean anomalies of the ſun and moon out of the Tables for 29 days 12 hours 44m. 3s.; take alſo the mean motion of the ſun, and of the moon's node, out of their proper Tables for the ſame time; their ſum is the ſun's mean diſtance from the moon's node. Having found the numbers for one lunation, multiply them by 2, 3, 4, &c. until there are 13 products, and divide the numbers for one lunation by 2 for the half lunation.

By theſe Tables the times of mean ſyzygies for any month of a given year, within the limits of Table 1. may be found.

The

The Tables of equations for reducing the mean to the true times of new and full moons, in the following pages, depend on the mean anomalies of the ſun and moon, with the ſun's mean diſtance from the moon's node, and are expreſſed in time for the conveniency of calculation. The method of applying them is given in Problem XXXII.

Tables of the Mean Motions of the Planets Mercury, Venus, &c. with the Logarithms of their Diſtances from the Sun, and of their proper equations, p. 72—120.

These Tables are conſtructed much in the ſame manner as thoſe of the ſun and moon, with this difference, that the mean anomaly of the planets are left out, and only the mean longitude of the planet, of its apogee, and node, are inſerted. The mean anomaly of any planet is found by ſubtracting the longitude of its apogee from that of the planet.

The uſe of the Tables of each planet, both of mean motions and equations, is clearly explained in Problem XXI. whereby their longitudes and latitudes for any given time and place may be found.

Conſtruction and Uſe of Logiſtical Logarithms, p. 128.

Logistical Logarithms are artificial numbers deduced from common logarithms, and made for minutes and ſeconds either of degrees or time, uſed in working proportions, wherein ſome or all of the given terms are ſexageſimals.

The numbers which compoſe the Table of logiſtical logarithms are regulated by its extent. For if the Table contains no more than the minutes and ſeconds in 1°, or 3600″, the logiſtical logarithm of 1″ is the logarithm of 3600″, *viz.* 3.5563; and all the following numbers are the differences between 3.5563 and the logarithms of the ſeveral numbers of ſeconds

ſeconds from 1 to 3600″. Therefore to calculate the logiſtical logarithm of any quantity leſs than 1°, ſubtract the logarithm of the given number of ſeconds from 3.5563; the remainder is the logiſtical logarithm required.

EXAM. Let it be required to find the logiſtical logarithm of 10′, or 600″?

From the common log. of 3600 = 3.5563
Subtract the common log. of 600 = 2.7781

There remains the logiſtical log. of 10 = 0.7782

But if the Table is to contain more than 1°, ſuch as in Mr Maſkelyne's Proportional Logarithms, which extends to 3°, or 10800″; then, in ſuch a Table, the proportional or logiſtical logarithm of 1″ is the logarithm of 10800, *viz.* 4.0334; and all the reſt are the differences between 4.0334 and the logarithms of the ſeveral numbers of ſeconds from 1 to 10800″

EXAM. Let it be required to find the logiſtical or proportional log. of 10′ or 600″?

From the log. of - -	10800 =	4.0334
Subtract the log. of - -	600 =	2.7781
Remains the prop. log. of -	10′	1.2553

Hence there may be as many different ſyſtems of logiſtical or proportional logarithms as any one chooſes to aſſume different extents of the Table. Our Table extends only from 1″ to 1°, which is ſufficient for common uſe. Logiſtical logarithms conſiſt of four figures beſides the index.

The numbers on the head of the Table are either degrees or minutes; and thoſe in the left hand column, on the ſide, are minutes or ſeconds: but if the numbers on the head be hours or minutes, thoſe in the left hand column, on the ſide, will be minutes or ſeconds of time. Therefore theſe numbers change their denomination as occaſion requires. The ſecond

line

line on the head of the Table are the numbers of ſeconds in the minutes which ſtand over them.

To take the logiſtical logarithm of any number of minutes and ſeconds out of the Table, the given number muſt be within the limits of the Table.

Find the minutes on the head of the Table, and the ſeconds in the left hand column on the ſide, and under the minutes and oppoſite to the ſeconds ſtands the logiſtical logarithm required.

EXAMPLES.

	′	″		
Given numbers	0	40	Logiſt. log.	1.9542
	1	10		1.7112
	7	40		8935
	9	15		8120
	50	0		792
	50	37		739

A logiſtical logarithm being given, to find the number of minutes and ſeconds anſwering.

If the given logarithm be found in the Table, the minutes are on the head of the column and the ſeconds on the ſide; but if it be not found exactly in the Table, take the next greater than it, and the minutes and ſeconds anſwering are found on the head and ſide of the Table, as before.

EXAMPLES.

L. Log.	Values.
	m. s.
1.7112	1 10
9823	6 15
6746	12 41
5175	18 13

When the logiſtical logarithm of any number leſs than 3600 is required, find it, or the neareſt leſs, in the ſecond line on the head of the Table; and below the number on the

head, and oppoſite to its exceſs on the ſide, ſtands the logiſtical logarithm. Thus the logiſtical logarithm of 1276 is 4505.

Logiſtical logarithms are uſed in finding a fourth proportional, when ſome, or all of the given terms, are minutes and ſeconds either of motion or time; and the method of operation is the ſame as in working with common logarithms, that is, by adding the logarithms of the ſecond and third terms, and ſubtracting the logarithm of the firſt term from the ſum, the remainder is the logarithm of the fourth term, or anſwer.

EXAM. 1. Suppoſe the ſun's hourly motion was 2′ 27″, and it were required to find his motion in 47m. 10s.? The anſwer is 1′ 55″.

As 60m.	0
To 2′ 27″	13890
So 47m. 10s.	1045
To 1′ 55″	14935

2. Suppoſe the hourly motion of the moon from the ſun is 32′ 8″, and the moon is 58′ 12″ behind the ſun: In what time will the moon overtake the ſun? *Anſ.* 1h. 48m. 40s.

N. B. In ſuch queſtions, when the fourth proportional would exceed 60m. which is beyond the limit of the Table, take $\frac{1}{2}$, $\frac{1}{3}$, or $\frac{1}{4}$, of the third term, and multiply the fourth term, when found, by 2, 3, or 4.

As 32′ 8″	2712
To 60m.	0
So 29′ 6″	3143
To 54m. 20s.	431
2	
Doubled is 1h. 48m. 40s. the anſwer.	

In like manner, when two of the given terms exceed the limits of the Table, divide all the terms by ſome number, ſuch as 2, 3, or 4, and multiply the anſwer by the ſame number which divided the given terms.

Suppoſe

Suppoſe we have,	Half of each term.	
As 76′ 34″	38′ 17″	1951
Is to 24h.	12h.	6990
So is 64′ 20″	32′ 10″	2707
To 20h. 10m. nearly	10h. 5m.	9697
Doubled	20h. 10m.	7746

Tables of the Riſing of the Sun, p. 142, 143.

These Tables are ſeminocturnal arches, calculated for latitude 56° N. and for every 10 minutes of declination from 0 to 26° 50′ or very near 27°, and ſerve to find the apparent time of the riſing or ſetting of the ſun, or of any ſtar, its declination being leſs than 27 degrees.

The degrees of declination are marked in the left hand column on the ſide, and the minutes from the left towards the right hand on the head of the Table, proceeding from 0′ to 10′, 20′, 30′, 40′, 50′, which is exact enough for common uſe; for in this latitude a difference of 10′ of declination gives only about 1 minute difference of time in the ſeminocturnal arc; the declination being below 17°; and even when the declination is 27°, the difference does not amount to 2 minutes of time.

In calculating the Table the horizontal refraction 33′ was taken into the account, that the Table might exhibit the apparent time when the centre of the ſun, or of any ſtar, is at the true horizon.

To find the Time of Sun-riſing any given Day by the Table.

Compute the ſun's declination at the eſtimate time of riſing, and enter the Table with the degrees of declination on the ſide, and the minutes on the head; and oppoſite to the degrees, and below the minutes, ſtands the apparent time of ſun-riſing, reckoned from the preceding midnight.

Exam.

EXAM. 1. What time does the ſun riſe Feb. 14th, 1797, in latitude 56° N.? *Anſ.* 7h. 14m. 40s.

The eſtimate time of ſun-riſing, Feb. 14th, is about 7 h. in the morning. The ſun's declination then is about 12° 50′ ſouth.

And oppoſite to 12°, and below 50′, ſtands 7h. 14 m. 40s. the time of ſun-riſing.

To find the Time of Sun-ſetting any given Day by the Table.

CALCULATE the ſun's declination for the eſtimate time of his ſetting, and find the time of ſun-riſing when he hath that declination; ſubtract this time from 12 hours, and the remainder is the time of ſun-ſetting.

EXAM. It is required to find the time of ſun-ſetting 14th February, 1796, at Edinburgh, in latitude 56° N.? *Anſ.* 4h. 46m. 25s.

The eſtimate time of ſun-ſetting is about 5 h. afternoon. At that time the ſun's declination is 12° 40′ S.; when the ſun hath this declination, he riſes at 7h. 13m. 35s. in the morning.

	h.	m.	s.
From - - - -	12	0	0
Subtract - - -	7	13	35
Sun ſets at - - -	4	46	25

To find the Time of the Riſing or Setting of any Planet or Fixed Star, whoſe Declination is leſs than 27°, in the Latitude of 56° N. by the Table.

CALCULATE the time when the planet or ſtar is on the meridian by Problem XXIV.; and then enter the Table with the declination of the planet or ſtar, and take its ſeminocturnal arch; ſubtract this from 12 hours, and the remainder is its ſemidiurnal arch; which being applied to the time when the planet or ſtar is on the meridian, the time of its riſing or ſetting will be known.

ASTRONOMICAL

ASTRONOMICAL TABLES.

TABLE. *Containing the* LATITUDES *and* LONGITUDES *of ſome famous Cities and Places, with the* DIFFERENCE OF TIME *between their Meridians and that of Greenwich.*

Names of Places.		Latitude.				Longitude.				Diff. of time.			
		°	′	″		°	′	″		h.	m.	″	
Aberdeen	Scotland	57	9	0	N	2	6	15	W	0	8	25	+
Abo	Sweden	60	27	10	N	18	6	30	E	1	12	26	−
Aleppo	Syria	35	45	0	N	37	25	0	E	2	29	40	−
Algiers	Africa	36	49	30	N	2	12	45	E	0	8	51	−
Amſterdam	Holland	52	22	45	N	4	45	30	E	0	19	2	−
Antwerp	Netherla.	51	13	15	N	4	22	30	E	0	17	30	−
Athens	Greece	38	5	0	N	23	52	30	E	1	35	30	−
Bantam	Iſle Java	6	15	0	S	106	25	0	E	7	5	40	−
Barcelona	Spain	41	26	0	N	2	18	0	E	0	9	12	−
Bengal	India	22	0	0	N	92	45	0	E	6	11	0	−
Bergen	Norway	60	10	0	N	6	14	0	E	0	24	56	−
Berlin	Germany	52	32	30	N	13	26	0	E	0	53	44	−
Bermuda iſles		32	35	0	N	63	32	0	W	4	14	8	+
Boſton	America	42	25	0	N	70	37	0	W	4	42	28	+
Botany Bay	New Hol.	34	0	0	S	151	28	0	E	10	5	52	−
Breſt	France	48	23	0	N	4	30	0	W	0	18	0	+
Bridgetown	Barbadoes	13	0	0	N	59	50	0	W	3	59	20	+
Briſtol	England	51	28	0	N	2	30	0	W	0	10	0	+
Cadiz	Spain	36	33	30	N	6	7	0	W	0	24	28	+
Cairo	Egypt	30	2	30	N	31	26	15	E	2	5	45	−
Canton	China	23	8	0	N	113	2	0	E	7	32	8	−
Cape of G. Hope	Africa	33	55	15	S	18	29	0	E	1	13	56	−
Conſtantinople	Turkey	41	0	0	N	28	53	0	E	1	55	32	−
Copenhagen	Denmark	55	40	45	N	12	44	15	E	0	50	57	−
Dantzic	Poland	54	22	0	N	18	36	30	E	1	14	26	−
Dover	England	51	7	0	N	1	19	0	E	0	5	16	−
Dublin	Ireland	53	12	0	N	6	55	0	W	0	27	40	+
Dundee	Scotland	56	26	0	N	2	48	0	W	0	11	12	+

Names of Places.		Latitude.				Longitude.				Diff. of time.		
		°	′	″		°	′	″		h.	m.	″
Edinburgh	Scotland	55	58	0	N	3	6	15	W	0	12	25+
Iſle Ferro	Canaries	27	48	0	N	18	6	0	W	1	12	24+
Gibraltar	Spain	36	5	0	N	4	46	0	W	0	19	4+
Glaſgow	Scotland	55	52	0	N	4	5	0	W	0	16	20+
Gottenburg	Sweden	57	42	0	N	11	22	45	E	0	45	31—
Greenwich	England	51	28	39	N	0	0	0		0	0	0
Halifax	America	44	46	0	N	63	20	0	W	4	13	20+
Hamburgh	Germany	53	41	0	N	10	38	0	E	0	42	32—
Inverneſs	Scotland	57	33	0	N	4	2	0	W	0	16	8+
Iſpahan	Perſia	32	25	0	N	52	55	0	E	3	31	40—
Jeruſalem	Holy L.	31	55	0	N	35	20	0	E	2	21	20—
Lizard	England	49	57	0	N	5	21	0	W	0	21	24+
Macao	China	22	12	44	N	113	46	0	E	7	35	4—
Madrid	Spain	40	25	0	N	3	45	30	W	0	15	2+
Moſcow	Ruſſia	55	45	20	N	37	45	15	E	2	31	1—
Naples	Italy	40	50	45	N	14	12	45	E	0	56	51—
North Cape	Lapland	71	10	0	N	25	55	0	E	1	43	40—
Paris Obſervatory	France	48	50	14	N	2	19	0	E	0	9	16—
St Peterſburg	Ruſſia	59	56	0	N	30	18	15	E	2	1	13—
Philadelphia	America	39	57	0	N	75	18	0	W	5	1	12+
Quebec	America	46	55	0	N	69	54	0	W	4	39	36+
Pekin	China	39	55	16	N	116	21	30	E	7	45	26—
Rome	Italy	41	53	54	N	12	27	15	E	0	49	49—
Siam	India	14	18	0	N	100	49	0	E	6	43	16—
Smyrna	Turkey in Aſia	38	28	7	N	27	18	45	E	1	49	15—
Stockholm	Sweden	59	22	0	N	18	12	0	E	1	12	48—
Venice	Italy	45	27	0	N	12	19	0	E	0	49	16—
Vienna	Germany	48	11	20	N	16	23	0	E	1	5	32—

TABLES OF THE SUN'S MEAN MOTIONS.

I. *The Sun's Mean Longitude and Anomaly in Julian Years.*

	Years.	M. Longitude.				M. Anomaly.			
		S.	°	′	″	S.	°	′	″
	1	11	29	45	40	11	29	44	35
	2	11	29	31	21	11	29	29	9
	3	11	29	17	2	11	29	13	44
B	4	0	0	1	51	11	29	57	27
	5	11	29	47	32	11	29	42	2
	6	11	29	33	13	11	29	26	37
	7	11	29	18	54	11	29	11	12
B	8	0	0	3	43	11	29	54	55
	9	11	29	49	23	11	29	39	29
	10	11	29	35	4	11	29	24	4
	11	11	29	20	45	11	29	8	39
B	12	0	0	5	34	11	29	52	22
	13	11	29	51	15	11	29	36	57
	14	11	29	36	55	11	29	21	31
	15	11	29	22	36	11	29	6	6
B	16	0	0	7	35	11	29	49	49
	17	11	29	53	6	11	29	34	24
	18	11	29	38	47	11	29	18	59
	19	11	29	24	27	11	29	3	33
B	20	0	0	9	17	11	29	47	17
B	40	0	0	18	33	11	29	34	33
B	60	0	0	27	50	11	29	21	50
B	80	0	0	37	6	11	29	9	6
B	100	0	0	46	23	11	28	56	23
B	200	0	1	32	46	11	27	52	46
B	300	0	2	19	9	11	26	49	9
B	400	0	3	5	32	11	25	45	32
B	500	0	3	51	55	11	24	41	55

II. *The Precession of the Equinoctial Points.*

°	′	″
0	0	50.3
0	1	40.7
0	2	31.
0	3	21.4
0	4	11.7
0	5	2.1
0	5	52.4
0	6	42.8
0	7	33.1
0	8	23.5
0	9	13.8
0	10	4.2
0	10	54.5
0	11	44.9
0	12	35.2
0	13	25.6
0	15	15.9
0	15	6.3
0	15	56.6
0	16	47.
0	33	34
0	50	21
1	7	8
1	23	55
2	47	50
4	11	45
5	35	40
6	59	35

III. *Sun's Mean Longitude and Anomaly in Years current.*

Years.	M. Longitude.				M. Anomaly.				*Obliquity of the Ecliptic 1st January.*		
A. D.	S.	°	′	″	S.	°	′	″	°	′	″
1761	9	10	20	51	6	1	31	11	23	28	16
1781	9	10	30	7	6	1	18	27	23	28	9
1791	9	10	5	12	6	0	42	32	23	27	50
B 1792	9	10	50	1	6	1	26	15	23	27	48
1793	9	10	35	41	6	1	10	49	23	27	47
1794	9	10	21	22	6	0	55	24	23	27	48
1795	9	10	7	3	6	0	39	59	23	27	50
B 1796	9	10	51	52	6	1	23	42	23	27	52
1797	9	10	37	33	6	1	8	17	23	27	54
1798	9	10	23	13	6	0	52	51	23	27	55
1799	9	10	8	54	6	0	37	26	23	27	58
1800	9	9	54	35	6	0	22	1	23	28	0
1801	9	9	40	16	6	0	6	36	23	28	1
1802	9	9	25	56	5	29	51	10	23	28	0
1803	9	9	11	37	5	29	35	45	23	28	0
B 1804	9	9	56	26	6	0	19	28	23	27	58
1805	9	9	42	6	6	0	4	2	23	27	55
1806	9	9	27	48	5	29	48	38	23	27	51
1807	9	9	13	29	5	29	33	13	23	27	48
B 1808	9	9	58	17	6	0	16	48	23	27	44
1809	9	9	43	57	6	0	1	31	23	27	42
1810	9	9	29	37	5	29	45	57	23	27	40
1811	9	9	15	17	5	29	30	32	23	27	39
B 1812	9	10	0	5	6	0	14	15	23	27	39
1813	9	9	45	45	5	29	58	49	23	27	40
1814	9	9	31	25	5	29	43	26	23	27	41
1815	9	9	17	5	5	29	27	58	23	27	43
B 1816	9	10	1	53	6	0	11	41	23	27	46
1817	9	9	47	33	5	29	56	15	23	27	48
1818	9	9	33	13	5	29	40	50	23	27	50
1819	9	9	18	53	5	29	25	24	23	27	52
B 1820	9	10	3	41	6	0	9	7	23	27	52
1821	9	9	49	22	5	29	55	42	23	27	51
1841	9	9	58	39	5	29	42	59	23	27	59

TABLE IV. *The Sun's* MEAN LONGITUDE *and* ANOMALY *for* MONTHS *and* DAYS.

Days.	January.								February.							
	Longitude.				Anomaly.				Longitude.				Anomaly.			
	S.	°	′	″	S.	°	′	″	S.	°	′	″	S.	°	′	″
1	0	0	59	8	0	0	59	8	1	1	32	27	1	1	32	21
2	0	1	58	17	0	1	58	17	1	2	31	35	1	2	31	29
3	0	2	57	25	0	2	57	24	1	3	30	43	1	3	30	37
4	0	3	56	33	0	3	56	32	1	4	29	52	1	4	29	46
5	0	4	55	42	0	4	55	41	1	5	29	0	1	5	28	53
6	0	5	54	50	0	5	54	49	1	6	28	8	1	6	28	1
7	0	6	53	58	0	6	53	57	1	7	27	17	1	7	27	10
8	0	7	53	7	0	7	53	6	1	8	26	25	1	8	26	17
9	0	8	52	15	0	8	52	14	1	9	25	33	1	9	25	26
10	0	9	51	23	0	9	51	21	1	10	24	42	1	10	24	35
11	0	10	50	32	0	10	50	30	1	11	23	50	1	11	23	42
12	0	11	49	40	0	11	49	38	1	12	22	58	1	12	22	50
13	0	12	48	48	0	12	48	46	1	13	22	7	1	13	21	59
14	0	13	47	57	0	13	47	54	1	14	21	15	1	14	21	7
15	0	14	47	5	0	14	47	2	1	15	20	23	1	15	20	15
16	0	15	46	13	0	15	46	10	1	16	19	31	1	16	19	23
17	0	16	45	22	0	16	45	19	1	17	18	40	1	17	18	31
18	0	17	44	30	0	17	44	27	1	18	17	48	1	18	17	39
19	0	18	43	38	0	18	43	35	1	19	16	56	1	19	16	47
20	0	19	42	47	0	19	42	43	1	20	16	5	1	20	15	56
21	0	20	41	55	0	20	41	51	1	21	15	13	1	21	15	4
22	0	21	41	3	0	21	40	59	1	22	14	21	1	22	14	11
23	0	22	40	12	0	22	40	8	1	23	13	30	1	23	13	20
24	0	23	39	20	0	23	39	16	1	24	12	38	1	24	12	28
25	0	24	38	28	0	24	38	23	1	25	11	46	1	25	11	36
26	0	25	37	37	0	25	37	32	1	26	10	55	1	26	10	45
27	0	26	36	45	0	26	36	40	1	27	10	3	1	27	9	52
28	0	27	35	53	0	27	35	48	1	28	9	11	1	28	9	0
29	0	28	35	2	0	28	34	57								
30	0	29	34	10	0	29	34	5								
31	1	0	33	18	1	0	33	12								

In the months January and February of biſſextile years take away one day from the time.

Days.	March.								Days.	April.							
	Longitude.				Anomaly.					Longitude.				Anomaly.			
	S.	°	′	″	S.	°	′	″		S.	°	′	″	S.	°	′	″
1	1	29	8	20	1	29	8	9	1	2	29	41	38	2	29	41	22
2	2	0	7	28	2	0	7	17	2	3	0	40	46	3	0	40	30
3	2	1	6	36	2	1	6	25	3	3	1	39	55	3	1	39	38
4	2	2	5	45	2	2	5	34	4	3	2	39	3	3	2	38	46
5	2	3	4	53	2	3	4	42	5	3	3	38	11	3	3	37	54
6	2	4	4	1	2	4	3	49	6	3	4	37	20	3	4	37	3
7	2	5	3	10	2	5	2	58	7	3	5	36	28	3	5	36	11
8	2	6	2	18	2	6	2	6	8	3	6	35	36	3	6	35	18
9	2	7	1	26	2	7	1	14	9	3	7	34	45	3	7	34	27
10	2	8	0	35	2	8	0	22	10	3	8	33	53	3	8	33	35
11	2	8	59	43	2	8	59	30	11	3	9	33	1	3	9	32	43
12	2	9	58	51	2	9	58	38	12	3	10	32	10	3	10	31	52
13	2	10	58	0	2	10	57	47	13	3	11	31	18	3	11	30	59
14	2	11	57	8	2	11	56	55	14	3	12	30	26	3	12	30	7
15	2	12	56	16	2	12	56	3	15	3	13	29	35	3	13	29	16
16	2	13	55	25	2	13	55	11	16	3	14	28	43	3	14	28	24
17	2	14	54	33	2	14	54	19	17	3	15	27	51	3	15	27	32
18	2	15	53	41	2	15	53	27	18	3	16	27	0	3	16	26	40
19	2	16	52	50	2	16	52	36	19	3	17	26	8	3	17	25	48
20	2	17	51	58	2	17	51	44	20	3	18	25	16	3	18	24	56
21	2	18	51	6	2	18	50	51	21	3	19	24	25	3	19	24	5
22	2	19	50	15	2	19	50	0	22	3	20	23	33	3	20	23	13
23	2	20	49	23	2	20	49	8	23	3	21	22	41	3	21	22	21
24	2	21	48	31	2	21	48	16	24	3	22	21	50	3	22	21	29
25	2	22	47	40	2	22	47	25	25	3	23	20	58	3	22	20	37
26	2	23	46	48	2	23	46	33	26	3	24	20	6	3	24	19	45
27	2	24	45	56	2	24	45	40	27	3	25	19	15	3	25	18	54
28	2	25	45	5	2	25	44	53	28	3	26	18	23	3	26	18	2
29	2	26	44	13	2	26	43	57	29	3	27	17	31	3	27	17	9
30	2	27	43	21	2	27	43	5	30	3	28	16	40	3	28	16	18
31	2	28	42	30	2	28	42	14									

The Sun's MEAN LONGITUDE *and* ANOMALY *for* MONTHS *and* DAYS.

Days.	May. Longitude.				May. Anomaly.			
	S.	°	′	″	S.	°	′	″
1	3	29	15	48	3	29	15	26
2	4	0	14	56	4	0	14	34
3	4	1	14	5	4	1	13	43
4	4	2	13	13	4	2	12	51
5	4	3	12	21	4	3	11	58
6	4	4	11	30	4	4	11	7
7	4	5	10	38	4	5	10	15
8	4	6	9	46	4	6	9	23
9	4	7	8	55	4	7	8	32
10	4	8	8	3	4	8	7	40
11	4	9	7	11	4	9	6	47
12	4	10	6	20	4	10	5	56
13	4	11	5	28	4	11	5	4
14	4	12	4	36	4	12	4	12
15	4	13	3	45	4	13	3	21
16	4	14	2	53	4	14	2	28
17	4	15	2	1	4	15	1	36
18	4	16	1	10	4	16	0	45
19	4	17	0	18	4	16	59	53
20	4	17	59	26	4	17	59	1
21	4	18	58	35	4	18	58	10
22	4	19	57	43	4	19	57	17
23	4	20	56	51	4	20	56	25
24	4	21	56	0	4	21	55	34
25	4	22	55	8	4	22	54	42
26	4	23	54	16	4	23	53	50
27	4	24	53	25	4	24	52	58
28	4	25	52	33	4	25	52	6
29	4	26	51	41	4	26	51	14
30	4	27	50	50	4	27	50	23
31	5	28	49	58	4	28	49	31

Days.	June. Longitude.				June. Anomaly.			
	S.	°	′	″	S.	°	′	″
1	4	29	49	6	4	29	48	39
2	5	0	48	15	5	0	47	47
3	5	1	47	23	5	1	46	55
4	5	2	46	31	5	2	46	3
5	5	3	45	40	5	3	45	12
6	5	4	44	48	5	4	44	20
7	5	5	43	56	5	5	43	28
8	5	6	43	5	5	6	42	37
9	5	7	42	13	5	7	41	44
10	5	8	41	21	5	8	40	52
11	5	9	40	30	5	9	40	1
12	5	10	39	38	5	10	39	8
13	5	11	38	46	5	11	38	16
14	5	12	37	55	5	12	37	25
15	5	13	37	3	5	13	36	33
16	5	14	36	11	5	14	35	41
17	5	15	35	20	5	15	34	50
18	5	16	34	28	5	16	33	57
19	5	17	33	36	5	17	33	5
20	5	18	32	45	5	18	32	14
21	5	19	31	53	5	19	31	32
22	5	20	31	1	5	20	30	30
23	5	21	30	10	5	21	29	39
24	5	22	29	18	5	22	28	46
25	5	23	28	26	5	23	27	54
26	5	24	27	35	5	24	27	3
27	5	25	26	43	5	25	26	11
28	5	26	25	51	5	26	25	19
29	5	27	24	59	5	27	24	26
30	5	28	24	8	5	28	23	35

The Sun's MEAN LONGITUDE *and* ANOMALY *for* MONTHS *and* DAYS.

Days.	July.								Days.	August.							
	Longitude.				Anomaly.					Longitude.				Anomaly.			
	S.	°	′	″	S.	°	′	″		S.	°	′	″	S.	°	′	″
1	5	29	23	16	5	29	22	43	1	6	29	56	34	6	29	55	55
2	6	0	22	24	6	0	21	51	2	7	0	55	43	7	0	55	4
3	6	1	21	33	6	1	21	0	3	7	1	54	51	7	1	54	12
4	6	2	20	41	6	2	20	8	4	7	2	53	59	7	2	55	20
5	6	3	19	49	6	3	19	15	5	7	3	53	8	7	3	52	29
6	6	4	18	58	6	4	18	24	6	7	4	52	16	7	4	51	37
7	6	5	18	6	6	5	17	32	7	7	5	51	24	7	5	50	44
8	6	6	17	14	6	6	16	40	8	7	6	50	33	7	6	49	54
9	6	7	16	23	6	7	15	49	9	7	7	49	41	7	7	49	1
10	6	8	15	31	6	8	14	56	10	7	8	48	49	7	8	48	9
11	6	9	14	39	6	9	14	4	11	7	9	47	58	7	9	47	18
12	6	10	13	48	6	10	13	13	12	7	10	47	6	7	10	46	25
13	6	11	12	56	6	11	12	21	13	7	11	46	14	7	11	45	33
14	6	12	12	4	6	12	11	29	14	7	12	45	23	7	12	44	42
15	6	13	11	13	6	13	10	38	15	7	13	44	31	7	13	43	50
16	6	14	10	21	6	14	9	45	16	7	14	43	39	7	14	42	58
17	6	15	9	29	6	15	8	53	17	7	15	42	48	7	15	42	7
18	6	16	8	38	6	16	8	2	18	7	16	41	56	7	16	41	16
19	6	17	7	46	6	17	7	10	19	7	17	41	4	7	17	40	22
20	6	18	6	54	6	18	6	18	20	7	18	40	13	7	18	39	31
21	6	19	6	3	6	19	5	26	21	7	19	39	21	7	19	38	39
22	6	20	5	11	6	20	4	34	22	7	20	38	29	7	20	37	47
23	6	21	4	19	6	21	3	42	23	7	21	37	38	7	21	36	56
24	6	22	3	28	6	22	2	51	24	7	22	36	46	7	22	36	4
25	6	23	2	36	6	23	1	59	25	7	23	35	54	7	23	35	11
26	6	24	1	44	6	24	1	7	26	7	24	35	3	7	24	34	20
27	6	25	0	53	6	25	0	15	27	7	25	34	11	7	25	33	28
28	6	26	0	1	6	25	59	23	28	7	26	33	19	7	26	32	36
29	6	26	59	9	6	26	58	31	29	7	27	32	28	7	27	31	44
30	6	27	58	18	6	27	57	40	30	7	28	31	36	7	28	30	52
31	6	28	57	26	6	28	56	48	31	7	29	30	44	7	29	30	0

The Sun's MEAN LONGITUDE *and* ANOMALY *for* MONTHS *and* DAYS.

Days.	September.								Days.	October.							
	Longitude.				Anomaly.					Longitude.				Anomaly.			
	S.	°	′	″	S.	°	′	″		S.	°	′	″	S.	°	′	″
1	8	0	29	53	8	0	29	9	1	9	0	4	39	9	0	3	13
2	8	1	29	1	8	1	28	17	2	9	1	3	11	9	1	2	21
3	8	2	28	9	8	2	27	25	3	9	2	2	19	9	2	1	29
4	8	3	27	18	8	3	26	33	4	9	3	1	28	9	3	0	38
5	8	4	26	26	8	4	25	41	5	9	4	0	36	9	3	59	46
6	8	5	25	34	8	5	24	49	6	9	4	59	44	9	4	58	54
7	8	6	24	43	8	6	23	58	7	9	5	58	53	9	5	58	2
8	8	7	23	51	8	7	23	6	8	9	6	58	1	9	6	57	10
9	8	8	22	59	8	8	22	14	9	9	7	57	9	9	7	56	18
10	8	9	22	8	8	9	21	22	10	9	8	56	18	9	8	55	27
11	8	10	21	16	8	10	20	30	11	9	9	55	26	9	9	54	35
12	8	11	20	24	8	11	19	38	12	9	10	54	34	9	10	53	42
13	8	12	19	33	8	12	18	47	13	9	11	53	43	9	11	52	51
14	8	13	18	41	8	13	17	55	14	9	12	52	51	9	12	51	59
15	8	14	17	49	8	14	17	2	15	9	13	51	59	9	13	51	7
16	8	15	16	58	8	15	16	11	16	9	14	51	8	9	14	50	16
17	8	16	16	6	8	16	15	19	17	9	15	50	16	9	15	49	24
18	8	17	15	14	8	17	14	27	18	9	16	49	24	9	16	48	31
19	8	18	14	23	8	18	13	35	19	9	17	48	33	9	17	47	40
20	8	19	13	31	8	19	12	43	20	9	18	47	41	9	18	46	48
21	8	20	12	39	8	20	11	51	21	9	19	46	49	9	19	45	56
22	8	21	11	48	8	21	11	0	22	9	20	45	58	9	20	45	5
23	8	22	10	56	8	22	10	8	23	9	21	45	6	9	21	44	13
24	8	23	10	4	8	23	9	16	24	9	22	44	14	9	22	43	20
25	8	24	9	13	8	24	8	25	25	9	23	43	23	9	23	42	29
26	8	25	8	21	8	25	7	32	26	9	24	42	31	9	24	41	37
27	8	26	7	29	8	26	6	40	27	9	25	41	39	9	25	40	45
28	8	27	6	38	8	27	5	49	28	9	26	40	48	9	26	39	54
29	8	28	5	46	8	28	4	57	29	9	27	39	56	9	27	39	2
30	8	29	4	54	8	29	4	5	30	9	28	39	4	9	28	38	9
									31	9	29	38	13	9	29	37	18

The Sun's MEAN LONGITUDE *and* ANOMALY *for* MONTHS *and* DAYS.

Days.	November.								Days.	December.							
	Longitude.				Anomaly.					Longitude.				Anomaly.			
	S.	°	′	″	S.	°	′	″		S.	°	′	″	S.	°	′	″
1	10	0	37	21	10	0	36	26	1	11	0	11	31	11	0	10	30
2	10	1	36	29	10	1	35	34	2	11	1	10	39	11	1	9	38
3	10	2	35	38	10	2	34	43	3	11	2	9	47	11	2	8	46
4	10	3	34	46	10	3	33	50	4	11	3	8	56	11	3	7	55
5	10	4	33	54	10	4	32	58	5	11	4	8	4	11	4	7	3
6	10	5	33	3	10	5	32	7	6	11	5	7	12	11	5	6	11
7	10	6	32	11	10	6	31	15	7	11	6	6	21	11	6	5	20
8	10	7	31	19	10	7	30	23	8	11	7	5	29	11	7	4	27
9	10	8	30	27	10	8	29	30	9	11	8	4	37	11	8	3	35
10	10	9	29	36	10	9	28	39	10	11	9	3	46	11	9	2	44
11	10	10	28	44	10	10	27	47	11	11	10	2	54	11	10	1	52
12	10	11	27	52	10	11	26	55	12	11	11	2	2	11	11	1	0
13	10	12	27	1	10	12	26	4	13	11	12	1	11	11	12	0	8
14	10	13	26	9	10	13	25	12	14	11	13	0	19	11	12	59	16
15	10	14	25	17	10	14	24	19	15	11	13	59	27	11	13	58	24
16	10	15	24	26	10	15	23	28	16	11	14	58	36	11	14	57	33
17	10	16	23	34	10	16	22	36	17	11	15	57	44	11	15	56	41
18	10	17	22	42	10	17	21	44	18	11	16	56	52	11	16	55	48
19	10	18	21	50	10	18	20	52	19	11	17	56	1	11	17	54	57
20	10	19	20	59	10	19	20	0	20	11	18	55	9	11	18	54	5
21	10	20	20	7	10	20	19	8	21	11	19	54	17	11	19	53	13
22	10	21	19	16	10	21	18	17	22	11	20	53	26	11	20	52	22
23	10	22	18	24	10	22	17	25	23	11	21	52	34	11	21	51	29
24	10	23	17	32	10	23	16	33	24	11	22	51	42	11	22	50	37
25	10	24	16	41	10	24	15	41	25	11	23	50	51	11	23	49	46
26	10	25	15	49	10	25	14	49	26	11	24	49	59	11	24	48	54
27	10	26	14	57	10	26	13	57	27	11	25	49	7	11	25	48	2
28	10	27	14	6	10	27	13	6	28	11	26	48	16	11	26	47	11
29	10	28	13	14	10	28	12	14	29	11	27	47	24	11	27	46	18
30	10	29	12	22	10	29	11	22	30	11	28	46	32	11	28	45	26
									31	11	29	45	41	11	29	44	35

TABLE V. *Of the Sun's Mean Longitude and Anomaly for Hours, Minutes, and Seconds.*

H	′	″	‴		H	°	′	″	
	″	‴	iv.			′	″	‴	iv.
	‴	iv.	v.			″	‴	iv.	
1	2	27	50		31	1	16	23	
2	4	55	41		32	1	18	51	
3	7	23	31		33	1	21	19	
4	9	51	22		34	1	23	47	
5	12	19	12		35	1	26	14	
6	14	47	2		36	1	28	42	
7	17	14	53		37	1	31	10	
8	19	42	43		38	1	33	38	
9	22	10	34		39	1	36	6	
10	24	38	24		40	1	38	34	
11	27	6	14		41	1	41	1	
12	29	34	5		42	1	43	29	
13	32	1	55		43	1	45	57	
14	34	29	46		44	1	48	25	
15	36	57	36		45	1	50	53	
16	39	25	27		46	1	53	21	
17	41	53	17		47	1	55	48	
18	44	21	7		48	1	58	16	
19	46	48	58		49	2	0	44	
20	49	16	48		50	2	3	12	
21	51	44	39		51	2	5	40	
22	54	12	29		52	2	8	8	
23	56	40	19		53	2	10	36	
24	59	8	19		54	2	13	3	
25	61	36	9		55	2	15	31	
26	64	3	59		56	2	17	59	
27	66	31	49		57	2	20	27	
28	68	59	31		58	2	22	55	
29	71	27	21		59	2	25	23	
30	73	55	11		60	2	27	50	

TABLE VI. *Of Mean Refractions.*

Ap. Alts.	Refractions.		Ap. Alts.	Refractions.		Ap. Alts.	Refractions.	
°	′	″	°	′	″	°	′	″
0	33	0	30	1	38	60	0	33
1	24	29	31	1	35	61	0	32
2	18	35	32	1	31	62	0	30
3	14	30	33	1	28	63	0	29
4	11	51	34	1	24	64	0	28
5	9	54	35	1	21	65	0	26
6	8	28	36	1	18	66	0	25
7	7	20	37	1	16	67	0	24
8	6	29	38	1	13	68	0	23
9	5	48	39	1	10	69	0	22
10	5	15	40	1	8	70	0	21
11	4	47	41	1	5	71	0	19
12	4	23	42	1	3	72	0	18
13	4	3	43	1	1	73	0	17
14	3	45	44	0	59	74	0	16
15	3	30	45	0	57	75	0	15
16	3	17	46	0	55	76	0	14
17	3	4	47	0	53	77	0	13
18	2	54	48	0	51	78	0	12
19	2	44	49	0	49	79	0	11
20	2	35	50	0	48	80	0	10
21	2	27	51	0	46	81	0	9
22	2	20	52	0	44	82	0	8
23	2	14	53	0	43	83	0	7
24	2	7	54	0	41	84	0	6
25	2	2	55	0	40	85	0	5
26	1	56	56	0	38	86	0	4
27	1	51	57	0	37	87	0	3
28	1	47	58	0	35	88	0	2
29	1	42	59	0	34			

TABLE VII. *Equations of the Sun's Centre.*

Argument. Sun's Mean Anomaly.

Signs	—0			—1			—2			—3			—4			—5			
°	°	′	″	°	′	″	°	′	″	°	′	″	°	′	″	°	′	″	°
0	0	0	0	0	56	47	1	39	6	1	55	37	1	41	12	0	58	53	30
1	0	1	59	0	58	30	1	40	7	1	55	39	1	40	12	0	57	7	29
2	0	3	57	1	0	12	1	41	6	1	55	38	1	39	10	0	55	19	28
3	0	5	56	1	1	53	1	42	3	1	55	36	1	38	6	0	53	30	27
4	0	7	54	1	3	33	1	42	59	1	55	31	1	37	0	0	51	40	26
5	0	9	52	1	5	12	1	43	52	1	55	24	1	35	52	0	49	49	25
6	0	11	50	1	6	50	1	44	44	1	55	1	1	34	43	0	47	57	24
7	0	13	48	1	8	27	1	45	34	1	55	3	1	33	32	0	46	5	23
8	0	15	46	1	10	2	1	46	22	1	54	50	1	32	19	0	44	11	22
9	0	17	43	1	11	36	1	47	8	1	54	35	1	31	4	0	42	16	21
10	0	19	40	1	13	9	1	47	53	1	54	17	1	29	47	0	40	21	20
11	0	21	37	1	14	41	1	48	35	1	53	57	1	28	29	0	38	25	19
12	0	23	33	1	16	11	1	49	15	1	53	36	1	27	9	0	36	28	18
13	0	25	29	1	17	40	1	49	54	1	53	12	1	25	48	0	34	30	17
14	0	27	25	1	19	8	1	50	30	1	52	46	1	24	25	0	32	32	16
15	0	29	20	1	20	34	1	51	5	1	52	18	1	23	0	0	30	33	15
16	0	31	15	1	21	59	1	51	37	1	51	48	1	21	34	0	28	33	14
17	0	33	9	1	23	22	1	52	8	1	51	15	1	20	6	0	26	33	13
18	0	35	2	1	24	44	1	52	36	1	50	41	1	18	36	0	24	33	12
19	0	36	55	1	26	5	1	53	3	1	50	5	1	17	5	0	22	32	11
20	0	38	47	1	27	24	1	53	27	1	49	26	1	15	33	0	20	30	10
21	0	40	39	1	28	41	1	53	50	1	48	46	1	13	59	0	18	28	9
22	0	42	30	1	29	57	1	54	10	1	48	3	1	12	24	0	16	26	8
23	0	44	20	1	31	11	1	54	28	1	47	19	1	10	47	0	14	24	7
24	0	46	9	1	32	24	1	54	44	1	46	32	1	9	9	0	12	21	6
25	0	47	57	1	33	35	1	54	58	1	45	44	1	7	29	0	10	18	5
26	0	49	45	1	34	45	1	55	10	1	44	53	1	5	49	0	8	14	4
27	0	51	32	1	35	53	1	55	20	1	44	1	1	4	7	0	6	11	3
28	0	53	18	1	36	59	1	55	28	1	43	7	1	2	24	0	4	7	2
29	0	55	3	1	38	3	1	55	34	1	42	10	1	0	39	0	2	4	1
30	0	56	47	1	39	6	1	55	37	1	41	12	0	58	53	0	0	0	0
Signs	+11			+10			+9			+8			+7			+6			

TABLE VIII. *Logarithms of the Sun's Distance from the Earth.*

Argument. Sun's Mean Anomaly.

Signs °	0	1	2	°
0	5.007286	5.006347	5.003749	30
1	5.007285	5.006284	5.003640	29
2	5.007282	5.006220	5.003531	28
3	5.007277	5.006154	5.003420	27
4	5.007269	5.006087	5.003307	26
5	5.007260	5.006018	5.003194	25
6	5.007249	5.005946	5.003080	24
7	5.007235	5.005872	5.002965	23
8	5.007218	5.005797	5.002849	22
9	5.007200	5.005720	5.002732	21
10	5.007180	5.005642	5.002614	20
11	5.007158	5.005562	5.002495	19
12	5.007134	5.005480	5.002375	18
13	5.007107	5.005397	5.002254	17
14	5.007079	5.005312	5.002134	16
15	5.007048	5.005225	5.002012	15
16	5.007015	5.005136	5.001890	14
17	5.006980	5.005047	5.001767	13
18	5.006943	5.004956	5.001643	12
19	5.006905	5.004863	5.001518	11
20	5.006864	5.004768	5.001393	10
21	5.006821	5.004672	5.001268	9
22	5.006776	5.004575	5.001142	8
23	5.006730	5.004477	5.001016	7
24	5.006681	5.004377	5.000889	6
25	5.006630	5.004275	5.000762	5
26	5.006577	5.004173	5.000635	4
27	5.006522	5.004069	5.000508	3
28	5.006466	5.003963	5.000380	2
29	5.006408	5.003857	5.000252	1
30	5.006347	5.003749	5.000124	0
Signs	11	10	9	

Logarithms of the Sun's Distance from the Earth.

Argument. Sun's Mean Anomaly.

Signs °	3	4	5	°
0	5.000124	4.996405	4.993620	30
1	4.999995	4.996292	4.993555	29
2	4.999867	4.996180	4.993491	28
3	4.999739	4.996069	4.993429	27
4	4.999611	4.995959	4.993369	26
5	4.999483	4.995850	4.993311	25
6	4.999354	4.995742	4.993255	24
7	4.999227	4.995636	4.993201	23
8	4.999099	4.995531	4.993150	22
9	4.998971	4.995427	4.993102	21
10	4.998844	4.995325	4.993055	20
11	4.998717	4.995224	4.993009	19
12	4.998590	4.995126	4.992966	18
13	4.998463	4.995028	4.992926	17
14	4.998336	4.994932	4.992888	16
15	4.998210	4.994836	4.992852	15
16	4.998084	4.994743	4.992818	14
17	4.997960	4.994652	4.992786	13
18	4.997837	4.994562	4.992757	12
19	4.997714	4.994474	4.992731	11
20	4.997591	4.994387	4.992706	10
21	4.997468	4.994302	4.992683	9
22	4.997347	4.994219	4.992663	8
23	4.997226	4.994138	4.992646	7
24	4.997106	4.994058	4.992631	6
25	4.996987	4.993980	4.992618	5
26	4.996868	4.993904	4.992607	4
27	4.996750	4.993831	4.992599	3
28	4.996634	4.993759	4.992593	2
29	4.996519	4.993688	4.992590	1
30	4.996405	4.993620	4.992589	0
Signs	8	7	6	

TABLE IX. *The Sun's Declination to every Degree of his Longitude.*

Argument. Sun's Longitude.

Deg.	0 ♈ North. 6 ♎ South. ☉ Declin.	1 ♉ North. 7 ♏ South. ☉ Declin.	2 ♊ North. 8 ♐ South. ☉ Declin.	Deg.
	° ′ ″	° ′ ″	° ′ ″	
0	0 0 0	11 29 5	20 10 25	30
1	0 23 53	11 50 6	20 22 57	29
2	0 47 47	12 10 56	20 35 7	28
3	1 11 39	12 31 34	20 46 55	27
4	1 35 30	12 51 59	20 58 20	26
5	1 59 20	13 12 12	21 9 21	25
6	2 23 8	13 32 12	21 19 59	24
7	2 46 54	13 51 58	21 30 13	23
8	3 10 37	14 11 30	21 40 3	22
9	3 34 17	14 30 48	21 49 29	21
10	3 57 54	14 49 52	21 58 30	20
11	4 21 27	15 8 40	22 7 6	19
12	4 44 57	15 27 13	22 15 17	18
13	5 8 22	15 45 30	22 23 3	17
14	5 31 42	16 3 31	22 30 24	16
15	5 54 57	16 21 16	22 37 18	15
16	6 18 6	16 38 44	22 43 47	14
17	6 41 9	16 55 55	22 49 50	13
18	7 4 6	17 12 48	22 55 27	12
19	7 26 57	17 29 23	23 0 38	11
20	7 49 41	17 45 40	23 5 22	10
21	8 12 17	18 1 38	23 9 39	9
22	8 34 45	18 17 18	23 13 29	8
23	8 57 5	18 32 38	23 16 53	7
24	9 19 17	18 47 38	23 19 50	6
25	9 41 19	19 2 18	23 22 20	5
26	10 3 12	19 16 37	23 24 22	4
27	10 24 56	19 30 35	23 25 57	3
28	10 46 30	19 44 13	23 27 5	2
29	11 7 53	19 57 30	23 27 46	1
30	11 29 5	20 10 25	23 28 0	0
D	☉ Declin. 11 ♓ South. 5 ♍ North.	☉ Declin. 10 ♒ South. 4 ♌ North.	☉ Declin. 9 ♑ South. 3 ♋ North.	D

TABLE X. *Of the Sun's Apparent Semidiameter and Hourly Motion.*

Argument. Sun's Mean Anomaly.

Signs	0				1				2				3				4				5				
	Semidiam.		Hour. M.		Semidiam.		Hour. M.		Semidiam.		Hour. M.		Semidiam.		Hour. M.		Semidiam.		Hour. M.		Semidiam.		Hour. M.		
°	′	″	′	″	′	″	′	″	′	″	′	″	′	″	′	″	′	″	′	″	′	″	′	″	°
0	15	47	2	23	15	49	2	24	15	55	2	25	16	3	2	28	16	11	2	30	16	17	2	32	30
10	15	47	2	23	15	51	2	24	15	57	2	26	16	5	2	29	16	13	2	31	16	18	2	33	20
20	15	49	2	23	15	52	2	25	16	0	2	27	16	8	2	30	16	15	2	32	16	19	2	33	10
30	15	49	2	24	15	55	2	25	16	3	2	28	16	11	2	30	16	17	2	32	16	19	2	33	0
Signs	11				10				9				8				7				6				

TABLE XI. *Of the* EQUATION *of* TIME *fitted to each* DEGREE *of the* ECLIPTIC. *Place of the Apogee* 3^{s} 9°.

Argument. Sun's Longitude.

Deg.	♈ 0	♉ 1	♊ 2	♋ 3	♌ 4	♍ 5
	+ −		− +	+	+	+ −
	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.
0	7 36	1 9	3 51	1 13	5 57	2 20
1	7 17	1 23	3 47	1 26	5 59	2 4
2	6 58	1 36	3 41	1 40	6 0	1 48
3	6 39	1 48	3 37	1 55	6 1	1 31
4	6 20	2 0	3 32	2 7	6 1	1 14
5	6 1	2 11	3 26	2 20	6 0	0 56
6	5 42	2 22	3 19	2 33	5 59	0 38
7	5 24	2 32	3 12	2 45	5 57	0 20
8	5 5	2 42	3 4	2 58	5 54	+ 1
9	4 47	2 51	2 56	3 11	5 51	− 18
10	4 28	3 0	2 47	3 23	5 47	0 37
11	4 9	3 8	2 38	3 35	5 42	0 57
12	3 50	3 16	2 29	3 46	5 37	1 17
13	3 32	3 23	2 19	3 58	5 31	1 38
14	3 13	3 30	2 8	4 9	5 24	1 58
15	2 55	3 36	1 57	4 19	5 17	2 19
16	2 37	3 41	1 46	4 29	5 9	2 40
17	2 19	3 46	1 35	4 39	5 1	3 1
18	2 1	3 50	1 23	4 48	4 52	3 22
19	1 43	3 53	1 11	4 57	4 43	3 44
20	1 26	3 56	0 59	5 5	4 33	4 5
21	1 9	3 58	0 46	5 13	4 22	4 26
22	0 52	4 0	0 34	5 20	4 11	4 47
23	0 36	4 1	0 21	5 27	3 50	5 9
24	0 20	4 1	− 8	5 33	3 46	5 30
25	+ 4	4 1	+ 5	5 39	3 33	5 32
26	− 11	4 0	0 19	5 44	3 19	6 13
27	0 26	3 59	0 31	5 48	3 4	6 35
28	0 40	3 57	0 46	5 52	2 50	6 56
29	0 53	3 54	0 59	5 55	2 35	7 17
30	1 9	3 51	1 13	5 57	2 20	7 28

The equations with + are to be added to the apparent time to have the mean time; thoſe with − are to be ſubtracted from the apparent for the mean time.

Of the EQUATION *of* TIME *fitted to each* DEGREE *of the* ECLIPTIC. *Place of the Apogee* 3^{s} 9°.

Argument. Sun's Longitude.

Deg.	♎ 6 —	♏ 7 —	♐ 8 —	♑ 9 — +	♒ 10 +	♓ 11 +
	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.
0	7 38	15 31	13 33	1 11	11 28	14 19
1	7 58	15 39	13 17	0 42	11 45	14 13
2	8 19	15 46	13 0	— 12	12 1	14 6
3	8 40	15 52	12 42	+ 17	12 17	13 59
4	9 1	15 57	12 23	0 46	12 32	13 51
5	9 21	16 2	12 4	1 16	12 46	13 43
6	9 41	16 6	11 44	1 45	12 59	13 34
7	10 1	16 9	11 23	2 14	13 12	13 24
8	10 20	16 11	11 1	2 43	13 24	13 14
9	10 39	16 13	10 39	3 11	13 35	13 3
10	10 57	16 13	10 16	3 39	13 45	12 51
11	11 15	16 13	9 53	4 7	13 54	12 39
12	11 33	16 12	9 29	4 35	14 2	12 27
13	11 51	16 10	9 5	5 2	14 9	12 14
14	12 8	16 7	8 40	5 29	14 16	12 0
15	12 25	16 4	8 14	5 56	14 22	11 46
16	12 41	16 0	7 48	6 22	14 27	11 31
17	12 57	15 55	7 22	6 48	14 31	11 16
18	13 12	15 49	6 55	7 13	14 35	11 1
19	13 27	15 42	6 28	7 37	14 38	10 46
20	13 42	15 35	6 0	8 1	14 40	10 30
21	13 56	15 26	5 32	8 24	14 41	10 14
22	14 9	15 17	5 4	8 47	14 42	9 58
23	14 21	15 7	4 36	9 9	14 41	9 41
24	14 33	14 56	4 8	9 31	14 40	9 24
25	14 44	14 44	3 39	9 53	14 39	9 6
26	14 53	14 31	3 10	10 14	14 37	8 48
27	15 5	14 17	2 41	10 34	14 34	8 30
28	15 14	14 3	2 11	10 53	14 30	8 12
29	15 23	13 48	1 41	11 11	14 25	7 54
30	15 31	13 33	1 11	11 28	14 19	7 36

TABLE XII. *The* EQUATION *of* TIME *for every* DAY *in the* YEAR.

Days.	January. +		Feb. +		March. +		April. ±		May. −		June. ∓	
	m.	s.	m.	s.	m.	s.	m.	s.	m.	s.	m.	s.
1	4	13	14	6	12	37	3	52	3	10	2	39
2	4	41	14	13	12	25	3	34	3	17	2	30
3	5	9	14	19	12	12	3	16	3	24	2	20
4	5	36	14	25	11	58	2	58	3	30	2	10
5	6	3	14	29	11	44	2	40	3	36	2	0
6	6	30	14	33	11	30	2	22	3	41	1	49
7	6	56	14	36	11	15	2	5	3	46	1	38
8	7	21	14	38	11	0	1	48	3	49	1	27
9	7	46	14	40	10	45	1	31	3	53	1	15
10	8	10	14	41	10	29	1	14	3	56	1	4
11	8	34	14	41	10	13	0	58	3	58	0	52
12	8	58	14	40	9	56	0	42	3	59	0	39
13	9	20	14	38	9	40	0	26	4	0	0	27
14	9	42	14	36	9	23	+	11	4	1	0	15
15	10	3	14	33	9	6	−	4	4	1	−	2
16	10	24	14	29	8	48	0	19	4	0	+	11
17	10	44	14	24	8	30	0	33	3	59	0	24
18	11	3	14	19	8	12	0	47	3	57	0	36
19	11	21	14	13	7	54	1	1	3	55	0	49
20	11	39	14	6	7	36	1	14	3	52	1	2
21	11	55	13	59	7	18	1	27	3	49	1	15
22	12	11	13	51	6	59	1	40	3	45	1	28
23	12	27	13	42	6	41	1	52	3	40	1	41
24	12	41	13	32	6	21	2	3	3	35	1	53
25	12	54	13	22	6	3	2	14	3	30	2	6
26	13	7	13	12	5	54	2	25	3	24	2	18
27	13	19	13	1	5	26	2	35	3	18	2	31
28	13	30	12	49	5	7	2	45	3	11	2	43
29	13	40	12	43	4	48	2	54	3	4	2	55
30	13	49			4	29	3	2	2	56	3	7
31	13	58			4	11			2	48		

TABLE XII. *The* EQUATION *of* TIME *for every* DAY *in the* YEAR.

Days.	July. +		Auguſt. +		Sept. −		Octob. −		Nov. −		Dec. ∓	
	m.	s.	m.	s.	m.	s.	m.	s.	m.	s.	m.	s.
1	3	19	5	51	0	18	10	25	16	13	10	29
2	3	30	5	48	0	37	10	44	16	13	10	6
3	3	41	5	43	0	56	11	2	16	12	9	42
4	3	52	5	38	1	15	11	20	16	11	9	17
5	4	3	5	33	1	35	11	38	16	9	8	52
6	4	13	5	27	1	54	11	55	16	7	8	26
7	4	23	5	20	2	14	12	12	16	3	8	0
8	4	33	5	13	2	34	12	28	15	58	7	33
9	4	42	5	5	2	55	12	44	15	53	7	6
10	4	51	4	56	3	15	13	0	15	47	6	39
11	4	59	4	47	3	36	13	15	15	40	6	11
12	5	7	4	38	3	56	13	29	15	32	5	43
13	5	14	4	28	4	17	13	43	15	23	5	14
14	5	21	4	17	4	38	13	57	15	13	4	45
15	5	28	4	5	4	59	14	10	15	3	4	26
16	5	34	3	54	5	20	14	23	14	52	3	47
17	5	39	3	41	5	41	14	35	14	40	3	18
18	5	44	3	28	6	2	14	46	14	28	2	48
19	5	48	3	15	6	23	14	57	14	14	2	18
20	5	52	3	1	6	44	15	7	13	59	1	48
21	5	55	2	47	7	5	15	16	13	44	1	18
22	5	57	2	32	7	26	15	25	13	28	0	48
23	5	59	2	16	7	47	15	33	13	11	0	18
24	6	1	2	1	8	7	15	41	12	54	+	11
25	6	2	1	45	8	28	15	47	12	35	0	41
26	6	2	1	28	8	48	15	53	12	16	1	11
27	6	2	1	11	9	8	15	59	11	56	1	41
28	6	1	0	54	9	28	16	3	11	35	2	11
29	5	59	0	36	9	47	16	7	11	14	2	40
30	5	57	0	18	10	6	16	9	10	52	3	9
31	5	55	0	0			16	11			3	38

TABLE XIII. *Reduction of the Ecliptic to the Equator.*

Argument. Longitude of the Points of the Ecliptic.

S.	— 0 — 6	— 1 — 7	— 2 — 8	
′ ″	° ′ ″	° ′ ″	° ′ ″	° ′
0 0	0 0 0	2 5 42	2 11 15	30 0
0 30	0 2 29	2 7 2	2 9 59	29 30
1 0	0 4 58	2 8 20	2 8 42	29 0
1 30	0 7 27	2 9 35	2 7 21	28 30
2 0	0 9 55	2 10 48	2 5 58	28 0
2 30	0 12 24	2 11 59	2 4 33	27 30
3 0	0 14 52	2 13 7	2 3 5	27 0
3 30	0 17 20	2 14 14	2 1 35	26 30
4 0	0 19 48	2 15 18	2 0 3	26 0
4 30	0 22 15	2 16 19	1 58 28	25 30
5 0	0 24 43	2 17 18	1 56 50	25 0
5 30	0 27 9	2 18 15	1 55 11	24 30
6 0	0 29 36	2 19 9	1 53 29	24 0
6 30	0 32 1	2 20 1	1 51 45	23 30
7 0	0 34 27	2 20 51	1 49 58	23 0
7 30	0 36 51	2 21 38	1 48 10	22 30
8 0	0 39 16	2 22 23	1 46 19	22 0
8 30	0 41 39	2 23 5	1 44 26	21 30
9 0	0 44 2	2 23 44	1 42 31	21 0
9 30	0 46 24	2 24 21	1 40 34	20 30
10 0	0 48 45	2 24 55	1 38 35	20 0
10 30	0 51 6	2 25 27	1 36 34	19 30
11 0	0 53 26	2 25 57	1 34 31	19 0
11 30	0 55 45	2 26 23	1 32 27	18 30
12 0	0 58 3	2 26 47	1 30 20	18 0
12 30	1 0 20	2 27 9	1 28 11	17 30
13 0	1 2 36	2 27 27	1 26 1	17 0
13 30	1 4 51	2 27 43	1 23 49	16 30
14 0	1 7 5	2 27 57	1 21 35	16 0
14 30	1 9 18	2 28 8	1 19 20	15 30
15 0	1 11 30	2 28 16	1 17 3	15 0
S.	+ 5 + 11	+ 4 + 10	+ 3 + 9	

TABLE XIII. *Reduction of the Ecliptic to the Equator.*

Argument. Longitude of the Points of the Ecliptic.

S.	— 0 — 6	— 1 — 7	— 2 — 8	
° ′	° ′ ″	° ′ ″	° ′ ″	° ′
15 0	1 11 30	2 28 16	1 17 3	15 0
15 30	1 13 40	2 28 21	1 14 44	14 30
16 0	1 15 50	2 28 24	1 12 24	14 0
16 30	1 17 58	2 28 24	1 10 2	13 30
17 0	1 20 5	2 28 21	1 7 39	13 0
17 30	1 22 10	2 28 15	1 5 14	12 30
18 0	1 24 14	2 28 7	1 2 49	12 0
18 30	1 26 17	2 27 56	1 0 21	11 30
19 0	1 28 19	2 27 42	0 57 53	11 0
19 30	1 30 19	2 27 26	0 55 23	10 30
20 0	1 32 17	2 27 7	0 52 53	10 0
20 30	1 34 14	2 26 45	0 50 21	9 30
21 0	1 36 9	2 26 20	0 47 48	9 0
21 30	1 38 3	2 25 53	0 45 14	8 30
22 0	1 39 55	2 25 23	0 42 39	8 0
22 30	1 41 46	2 24 50	0 40 4	7 30
23 0	1 43 35	2 24 14	0 37 27	7 0
23 30	1 45 22	2 23 36	0 34 50	6 30
24 0	1 47 7	2 22 55	0 32 12	6 0
24 30	1 48 51	2 22 11	0 29 33	5 30
25 0	1 50 32	2 21 25	0 26 54	5 0
25 30	1 52 12	2 20 36	0 24 14	4 30
26 0	1 53 50	2 19 44	0 21 34	4 0
26 30	1 55 26	2 18 50	0 18 53	3 30
27 0	1 57 0	2 17 52	0 16 12	3 0
27 30	1 58 32	2 16 53	0 13 31	2 30
28 0	2 0 2	2 15 50	0 10 49	2 0
28 30	2 1 31	2 14 45	0 8 7	1 30
29 0	2 2 57	2 13 38	0 5 25	1 0
29 30	2 4 21	2 12 27	0 2 42	0 30
30 0	2 5 42	2 11 15	0 0 0	0 0
S.	+ 5 + 11	+ 4 + 10	+ 3 + 9	S.

TABLE XIV. *The* SUN's LONGITUDE *for every* DAY *in the* YEAR, *at* NOON.

Days.	January.			February.			March.			April.			May.			June.		
	S.	°	′	S.	°	′	S.	°	′	S.	°	′	S.	°	′	S.	°	′
1	9	11	21	10	12	54	11	11	8	0	11	55	1	11	12	2	11	2
2	9	12	23	10	13	55	11	12	8	0	12	54	1	12	10	2	12	0
3	9	13	24	10	14	56	11	13	8	0	13	53	1	13	9	2	12	57
4	9	14	25	10	15	57	11	14	8	0	14	52	1	14	7	2	13	54
5	9	15	26	10	16	57	11	15	8	0	15	51	1	15	5	2	14	52
6	9	16	27	10	17	58	11	16	8	0	16	50	1	16	3	2	15	49
7	9	17	29	10	18	59	11	17	8	0	17	49	1	17	1	2	16	46
8	9	18	30	10	20	0	11	18	8	0	18	48	1	17	59	2	17	44
9	9	19	31	10	21	0	11	19	8	0	19	47	1	18	56	2	18	41
10	9	20	32	10	22	1	11	20	8	0	20	45	1	19	54	2	19	39
11	9	21	33	10	23	1	11	21	7	0	21	44	1	20	52	2	20	35
12	9	22	34	10	24	2	11	22	7	0	22	43	1	21	50	2	21	33
13	9	23	35	10	25	3	11	23	7	0	23	41	1	22	48	2	22	30
14	9	24	36	10	26	3	11	24	6	0	24	40	1	23	45	2	23	28
15	9	25	37	10	27	4	11	25	6	0	25	39	1	24	43	2	24	25
16	9	26	39	10	28	4	11	26	6	0	26	37	1	25	41	2	25	22
17	9	27	39	10	29	4	11	27	5	0	27	36	1	26	39	2	26	19
18	9	28	41	11	0	5	11	28	5	0	28	34	1	27	36	2	27	17
19	9	29	42	11	1	5	11	29	4	0	29	33	1	28	34	2	28	14
20	10	0	43	11	2	6	0	0	4	1	0	31	1	29	32	2	29	11
21	10	1	44	11	3	6	0	1	3	1	1	30	2	0	29	3	0	8
22	10	2	45	11	4	6	0	2	3	1	2	28	2	1	27	3	1	6
23	10	3	46	11	5	7	0	3	2	1	3	26	2	2	25	3	2	3
24	10	4	47	11	6	7	0	4	1	1	4	25	2	3	22	3	3	0
25	10	5	48	11	7	7	0	5	1	1	5	23	2	4	20	3	3	57
26	10	6	49	11	8	7	0	6	0	1	6	21	2	5	17	3	4	55
27	10	7	50	11	9	8	0	6	59	1	7	20	2	6	15	3	5	52
28	10	8	51	11	10	8	0	7	59	1	8	18	2	7	12	3	6	49
29	10	9	52				0	8	58	1	9	16	2	8	10	3	7	46
30	10	10	52				0	9	57	1	10	14	2	9	7	3	8	43
31	10	11	53				0	10	56				2	10	5			

TABLE XIV. *The Sun's Longitude for every Day in the Year, at Noon.*

Days.	July.			Auguſt.			Sept.			Octob.			Novem.			Decem.		
	S.	°	′	S.	°	′	S.	°	′	S.	°	′	S.	°	′	S.	°	′
1	3	9	41	4	9	17	5	9	7	6	8	26	7	9	15	8	9	32
2	3	10	38	4	10	14	5	10	6	6	9	25	7	10	15	8	10	33
3	3	11	35	4	11	11	5	11	4	6	10	24	7	11	16	8	11	34
4	3	12	32	4	12	9	5	12	2	6	11	24	7	12	16	8	12	35
5	3	13	30	4	13	6	5	13	0	6	12	23	7	13	16	8	13	36
6	3	14	27	4	14	4	5	13	59	6	13	22	7	14	16	8	14	37
7	3	15	24	4	15	2	5	14	57	6	14	21	7	15	17	8	15	38
8	3	16	21	4	15	59	5	15	55	6	15	21	7	16	17	8	16	39
9	3	17	18	4	16	57	5	16	53	6	16	20	7	17	17	8	17	40
10	3	18	15	4	17	54	5	17	52	6	17	19	7	18	18	8	18	41
11	3	19	13	4	18	52	5	18	50	6	18	19	7	19	18	8	19	42
12	3	20	10	4	19	49	5	19	49	6	19	18	7	20	19	8	20	43
13	3	21	7	4	20	47	5	20	47	6	20	18	7	21	19	8	21	44
14	3	22	4	4	21	45	5	21	46	6	21	17	7	22	20	8	22	45
15	3	23	2	4	22	42	5	22	44	6	22	17	7	23	20	8	23	47
16	3	23	59	4	23	40	5	23	43	6	23	17	7	24	21	8	24	48
17	3	24	56	4	24	38	5	24	42	6	24	16	7	25	21	8	25	49
18	3	25	53	4	25	36	5	25	40	6	25	16	7	26	22	8	26	50
19	3	26	51	4	26	33	5	26	39	6	26	16	7	27	23	8	27	51
20	3	27	48	4	27	31	5	27	38	6	27	16	7	28	23	8	28	52
21	3	28	45	4	28	29	5	28	37	6	28	15	7	29	24	8	29	54
22	3	29	43	4	29	27	5	29	35	6	29	15	8	0	25	9	0	55
23	4	0	40	5	0	25	6	0	34	7	0	15	8	1	26	9	1	56
24	4	1	37	5	1	23	6	1	33	7	1	15	8	2	26	9	2	57
25	4	2	35	5	2	21	6	2	32	7	2	15	8	3	27	9	3	58
26	4	3	32	5	3	19	6	3	31	7	3	15	8	4	28	9	4	59
27	4	4	29	5	4	17	6	4	30	7	4	15	8	5	29	9	6	1
28	4	5	27	5	5	15	6	5	29	7	5	15	8	6	30	9	7	2
29	4	6	24	5	6	13	6	6	28	7	6	15	8	7	31	9	8	3
30	4	7	22	5	7	11	6	7	27	7	7	15	8	8	32	9	9	4
31	4	8	19	5	8	9				7	8	15				9	10	5

TABLE XV. *The Sun's Right Ascension at Noon for every Day in the Year.*

Days.	January.		Feb.		March.		April.		May.		June.	
	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.
1	18	49	21	1	22	50	0	44	2	35	4	38
2	18	53	21	5	22	54	0	47	2	39	4	42
3	18	58	21	9	22	58	0	51	2	43	4	46
4	19	2	21	13	23	1	0	55	2	46	4	50
5	19	7	21	17	23	5	0	58	2	50	4	54
6	19	11	21	21	23	9	1	2	2	54	4	58
7	19	15	21	25	23	12	1	6	2	58	5	2
8	19	20	21	29	23	16	1	9	3	2	5	6
9	19	24	21	33	23	20	1	13	3	6	5	11
10	19	28	21	37	23	24	1	17	3	10	5	15
11	19	33	21	41	23	27	1	20	3	14	5	19
12	19	37	21	45	23	31	1	24	3	18	5	23
13	19	41	21	49	23	35	1	27	3	21	5	27
14	19	46	21	53	23	38	1	31	3	25	5	31
15	19	50	21	57	23	42	1	35	3	29	5	35
16	19	54	22	1	23	45	1	39	3	33	5	40
17	19	58	22	5	23	49	1	42	3	37	5	44
18	20	3	22	8	23	53	1	46	3	41	5	48
19	20	7	22	12	23	57	1	50	3	45	5	52
20	20	11	22	16	0	0	1	53	3	49	5	56
21	20	15	22	20	0	3	1	57	3	53	6	0
22	20	20	22	24	0	7	2	1	3	57	6	5
23	20	24	22	28	0	11	2	5	4	1	6	9
24	20	28	22	31	0	15	2	8	4	5	6	13
25	20	32	22	35	0	18	2	12	4	9	6	17
26	20	36	22	39	0	22	2	16	4	13	6	21
27	20	41	22	43	0	25	2	20	4	17	6	25
28	20	45	22	46	0	29	2	24	4	21	6	29
29	20	49			0	33	2	27	4	25	6	34
30	20	53			0	36	2	31	4	29	6	38
31	20	57			0	40			4	34		

TABLE XV. *The Sun's Right Ascension at Noon for every Day in the Year.*

Days.	July.		August.		Sept.		Octob.		Nov.		Dec.	
	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.	h.	m.
1	6	42	8	47	10	43	12	31	14	27	16	31
2	6	46	8	51	10	46	12	35	14	31	16	36
3	6	50	8	54	10	50	12	38	14	35	16	40
4	6	54	8	58	10	54	12	42	14	39	16	44
5	6	58	9	2	10	57	12	46	14	43	16	49
6	7	2	9	6	11	1	12	49	14	47	16	53
7	7	7	9	10	11	4	12	53	14	51	16	57
8	7	11	9	14	11	8	12	57	14	55	17	2
9	7	15	9	18	11	12	13	0	14	59	17	6
10	7	19	9	21	11	15	13	4	15	3	17	11
11	7	23	9	25	11	19	13	8	15	7	17	15
12	7	27	9	29	11	23	13	11	15	11	17	20
13	7	31	9	3	11	26	13	15	15	15	17	24
14	7	35	9	36	11	30	13	19	15	19	17	28
15	7	39	9	40	11	33	13	22	15	23	17	33
16	7	43	9	44	11	37	13	26	15	28	17	37
17	7	47	9	48	11	41	13	30	15	32	17	42
18	7	51	9	51	11	44	13	34	15	36	17	46
19	7	55	9	55	11	48	13	37	15	40	17	51
20	7	59	9	59	11	51	13	41	15	44	17	55
21	8	3	10	2	11	55	13	45	15	49	17	59
22	8	7	10	6	11	58	13	49	15	53	18	4
23	8	11	10	10	12	2	13	52	15	57	18	8
24	8	15	10	14	12	6	13	56	16	1	18	13
25	8	19	10	17	12	9	14	0	16	6	18	17
26	8	23	10	21	12	13	14	4	16	10	18	22
27	8	27	10	25	12	16	14	8	16	14	18	26
28	8	31	10	28	12	20	14	12	16	18	18	31
29	8	35	10	32	12	24	14	16	16	23	18	35
30	8	39	10	36	12	27	14	20	16	27	18	39
31	8	43	10	39			14	23			18	44

LUNAR TABLES.

TABLE I. *Of the Moon's Mean Motions in Julian Years.*

Years.		☽'s Mean Long.				☽'s Mean Anom.				☽'s ☊ Retrogade.			
		S.	°	′	″	S.	°	′	″	S.	°	′	″
	1	4	9	23	5	2	28	43	15	0	19	19	43
	2	8	18	46	11	5	27	26	30	1	8	39	26
	3	0	28	9	16	8	26	9	45	1	27	59	9
B	4	5	20	42	57	0	7	56	54	2	17	22	3
	5	10	0	6	2	3	6	40	9	3	6	41	46
	6	2	9	29	7	6	5	23	23	3	26	1	29
	7	6	18	52	13	9	4	6	39	4	15	21	12
B	8	11	11	25	53	0	15	53	47	5	4	44	6
	9	3	20	48	59	3	14	37	3	5	24	3	49
	10	8	0	12	4	6	13	20	17	6	13	23	32
	11	0	9	35	9	9	12	3	32	7	2	43	15
B	12	5	2	8	50	0	23	50	17	7	22	6	9
	13	9	11	31	55	3	22	33	56	8	11	25	52
	14	1	20	55	1	6	21	17	11	9	0	45	35
	15	6	0	18	6	9	20	0	26	9	20	5	18
B	16	10	22	51	46	1	1	47	34	10	9	28	12
	17	3	2	14	52	4	0	30	50	10	28	47	55
	18	7	11	37	57	6	29	14	4	11	18	7	38
	19	11	21	1	2	9	27	57	19	0	7	27	21
B	20	4	13	34	43	1	9	44	30	0	26	50	15
B	40	8	27	9	26	2	19	28	56	1	23	40	30
B	60	1	10	44	9	3	29	13	24	2	20	30	45
B	80	5	24	18	52	5	8	57	52	3	17	21	0
B	100	10	7	53	35	6	18	42	20	4	14	11	15
B	200	8	15	47	10	1	7	24	40	8	28	22	13
B	300	6	23	40	45	7	26	7	0	1	12	33	45
B	400	5	1	34	20	2	14	49	20	5	26	45	0
B	500	3	9	27	55	9	3	31	40	10	10	56	15

TABLE II. *The Moon's Mean Longitude and Anomaly for Current Years.*

A. D.	Mean Long.				Mean Anom.				Long. ☊.			
	S.	°	′	″	S.	°	′	″	S.	°	′	″
1761	7	1	8	8	10	12	34	50	2	7	33	33
1781	11	14	42	54	11	22	19	18	1	10	43	18
1791	7	14	54	59	6	5	39	35	6	27	19	46
1792	0	7	28	40	9	17	26	44	6	7	56	52
1793	4	16	51	45	0	16	9	59	5	18	37	9
1794	8	26	14	51	3	14	53	14	4	29	17	26
1795	1	5	37	57	6	13	36	29	4	9	57	43
B 1796	5	28	11	37	9	25	23	38	3	20	34	49
1797	10	7	34	43	0	24	6	53	3	1	15	6
1798	2	16	57	48	3	22	50	8	2	11	55	23
1799	6	26	20	54	6	21	33	23	1	22	35	40
1800	11	5	44	0	9	20	16	38	1	3	15	57
1801	3	15	7	5	0	18	59	52	0	13	56	14
1802	7	24	30	11	3	17	43	7	11	24	36	31
1803	0	3	53	16	6	16	26	22	11	5	16	48
B 1804	4	26	26	57	9	28	13	31	10	15	53	54
1805	9	5	50	2	0	26	56	46	9	26	34	11
1806	1	15	13	8	3	25	40	1	9	7	14	28
1807	5	24	36	14	6	24	23	16	8	17	54	45
B 1808	10	17	9	54	10	6	10	25	7	28	31	51
1809	2	26	33	0	1	4	53	40	7	9	12	8
1810	7	5	56	5	4	3	36	55	6	19	52	25
1811	11	15	19	11	7	2	20	9	6	0	32	42
B 1812	4	7	52	52	10	14	7	18	5	11	9	48
1813	8	17	15	57	1	12	50	33	4	21	50	5
1814	0	26	39	3	4	11	33	48	4	2	30	22
1815	5	6	2	8	7	10	17	3	3	13	10	39
B 1816	9	28	35	49	10	22	4	12	2	23	47	45
1817	2	7	58	55	1	20	47	27	2	4	28	2
1818	6	17	22	0	4	19	30	42	1	15	8	19
1819	10	26	45	6	7	18	13	57	0	25	48	36
B 1820	3	19	18	47	11	0	1	6	0	6	25	42
1821	7	28	41	54	1	28	44	21	11	17	5	59
1841	0	12	16	37	3	8	28	51	10	20	15	44

TABLE III. *The Moon's Mean Motions for Months and Days.*

Days.	January.											
	Mean Motion ☽.				Anomaly.				Motion ☊.			
	S.	°	′	″	S.	°	′	″	°	′	″	
1	0	13	10	35	0	13	3	54	0	3	11	
2	0	26	21	10	0	26	7	48	0	6	21	
3	1	9	31	45	1	9	11	42	0	9	32	
4	1	22	42	20	1	22	15	36	0	12	43	
5	2	5	52	55	2	5	19	30	0	15	53	
6	2	19	3	30	2	18	23	24	0	19	4	
7	3	2	14	5	3	1	27	18	0	22	14	
8	3	15	24	40	3	14	31	12	0	25	25	
9	3	28	35	15	3	27	35	6	0	28	36	
10	4	11	45	50	4	10	39	0	0	31	46	
11	4	24	56	25	4	23	42	53	0	34	57	
12	5	8	7	0	5	6	46	47	0	38	8	
13	5	21	17	35	5	19	50	41	0	41	18	
14	6	4	28	10	6	2	54	35	0	14	29	
15	6	17	38	45	6	15	58	29	0	47	40	
16	7	0	49	20	6	29	2	23	0	50	50	
17	7	13	59	55	7	12	6	17	0	54	1	
18	7	27	10	30	7	25	10	11	0	57	11	
19	8	10	21	5	8	8	14	5	1	0	22	
20	8	23	31	41	8	21	17	59	1	3	33	
21	9	6	42	16	9	4	41	53	1	6	43	
22	9	19	52	51	9	17	25	47	1	9	54	
23	10	3	3	26	10	0	29	41	1	13	5	
24	10	16	14	1	10	13	33	35	1	16	15	
25	10	29	24	36	10	26	37	29	1	19	26	
26	11	12	35	11	11	9	41	23	1	22	37	
27	11	25	45	46	11	22	45	17	1	25	47	
28	0	8	56	21	0	5	49	11	1	28	58	
29	0	22	6	56	0	18	53	5	1	32	8	
30	1	5	17	31	1	1	56	59	1	35	19	
31	1	18	28	6	1	15	0	53	1	38	30	

TABLE III. *The Moon's Mean Motions for Months and Days.*

Days.	February.											
	Mean Motion ☽.				Anomaly.				Motion ☊.			
	S.	°	′	″	S.	°	′	″	°	′	″
1	2	1	38	41	1	28	4	47	1	41	40
2	2	14	49	16	2	11	8	41	1	44	51
3	2	27	59	51	2	24	12	35	1	48	2
4	3	11	10	26	3	7	16	29	1	51	12
5	3	24	21	1	3	20	20	22	1	54	23
6	4	7	31	36	4	3	24	16	1	57	34
7	4	20	42	11	4	16	28	10	2	0	44
8	5	3	52	46	4	29	32	4	2	3	55
9	5	17	3	21	5	12	35	58	2	7	5
10	6	0	13	56	5	25	39	52	2	10	16
11	6	13	24	31	6	8	43	46	2	13	27
12	6	26	35	6	6	21	47	40	2	16	37
13	7	9	45	41	7	4	51	34	2	19	48
14	7	22	56	16	7	17	55	28	2	22	59
15	8	6	6	51	8	0	59	22	2	26	9
16	8	19	17	26	8	14	3	16	2	29	20
17	9	2	28	1	8	27	7	10	2	32	31
18	9	15	38	36	9	10	11	4	2	35	41
19	9	28	49	11	9	23	14	58	2	38	52
20	10	11	59	46	10	6	18	52	2	42	3
21	10	25	10	21	10	19	22	46	2	45	13
22	11	8	20	56	11	2	26	40	2	48	24
23	11	21	31	31	11	15	30	34	2	51	34
24	0	4	42	7	11	28	34	28	2	54	45
25	0	17	52	42	0	11	38	22	2	57	56
26	1	1	3	17	0	24	42	16	3	1	6
27	1	14	13	52	1	7	46	10	3	4	17
28	1	27	24	27	1	20	50	4	3	7	28

In January and February of a biſſextile year, ſubtract 1 from the number of days.

TABLE III. *The Moon's Mean Motions for Months and Days.*

Days.	March.											
	Mean Motion ☽.				Anomaly.				Motion ☊.			
	S.	°	′	″	S.	°	′	″	°	′	″	
1	2	10	35	2	2	3	53	57	3	10	38	
2	2	23	45	37	2	16	57	51	3	13	49	
3	3	6	56	12	3	0	1	45	3	17	0	
4	3	20	6	47	3	13	5	39	3	20	10	
5	4	3	17	22	3	26	9	33	3	23	21	
6	4	16	27	57	4	9	13	27	3	26	31	
7	4	29	38	32	4	22	17	21	3	29	42	
8	5	12	49	7	5	5	21	15	3	32	53	
9	5	25	59	42	5	18	25	9	3	36	3	
10	6	9	10	17	6	1	29	3	3	39	14	
11	6	22	20	52	6	14	32	57	3	42	25	
12	7	5	31	27	6	27	36	51	3	45	35	
13	7	18	42	2	7	10	40	45	3	48	46	
14	8	1	52	37	7	23	44	39	3	51	57	
15	8	15	3	12	8	6	48	33	3	55	7	
16	8	28	13	47	8	19	52	27	3	58	18	
17	9	11	24	22	9	2	56	21	4	1	28	
18	9	24	34	57	9	16	0	15	4	4	39	
19	10	7	45	32	9	29	4	9	4	7	50	
20	10	20	56	7	10	12	8	3	4	11	0	
21	11	4	6	42	10	25	11	57	4	14	11	
22	11	17	17	17	11	8	15	51	4	17	22	
23	0	0	27	52	11	21	19	45	4	20	32	
24	0	13	38	27	0	4	23	39	4	23	43	
25	0	26	49	2	0	17	27	32	4	26	34	
26	1	9	59	37	1	0	31	26	4	30	4	
27	1	23	10	12	1	13	35	20	4	33	15	
28	2	6	20	47	1	26	39	14	4	36	25	
29	2	19	31	22	2	9	43	8	4	39	36	
30	3	2	41	57	2	22	47	2	4	42	47	
31	3	15	52	33	3	5	50	56	4	45	57	

TABLE III. *The* MOON's MEAN MOTIONS *for* MONTHS *and* DAYS.

Days.	April.											
	Mean Motion ☽.				Anomaly.				Motion ☊.			
	S.	°	′	″	S.	°	′	″	°	′	″	
1	3	29	3	8	3	18	54	50	4	49	8	
2	4	12	13	43	4	1	58	44	4	52	19	
3	4	25	24	18	4	15	2	38	4	55	29	
4	5	8	34	53	4	28	6	32	4	58	40	
5	5	21	45	28	5	11	10	26	5	1	51	
6	6	4	56	3	5	24	14	20	5	5	1	
7	6	18	6	38	6	7	18	14	5	8	12	
8	7	1	17	13	6	20	22	8	5	11	23	
9	7	14	27	48	7	3	26	2	5	14	33	
10	7	27	38	23	7	16	29	56	5	17	44	
11	8	10	48	58	7	29	33	50	5	20	54	
12	8	23	59	33	8	12	37	44	5	24	5	
13	9	7	10	8	8	25	41	38	5	27	16	
14	9	20	20	43	9	8	45	32	5	30	26	
15	10	3	31	18	9	21	49	26	5	33	37	
16	10	16	41	53	10	4	53	20	5	36	48	
17	10	29	52	28	10	17	57	14	5	39	58	
18	11	13	3	3	11	1	1	7	5	43	9	
19	11	26	13	38	11	14	5	1	5	46	20	
20	0	9	24	13	11	27	8	55	5	49	30	
21	0	22	34	48	0	10	12	49	5	52	41	
22	1	5	45	23	0	23	16	43	5	55	51	
23	1	18	55	58	1	6	20	37	5	59	2	
24	2	2	6	33	1	19	24	31	6	2	13	
25	2	15	17	8	2	2	28	25	6	5	23	
26	2	28	27	43	2	15	32	19	6	8	34	
27	3	11	38	18	2	28	36	13	6	11	45	
28	3	24	48	53	3	11	40	7	6	14	55	
29	4	7	59	28	3	24	44	1	6	18	6	
30	4	21	10	3	4	7	47	55	6	21	17	

TABLE III. *The Moon's Mean Motions for Months and Days.*

Days.	May.											
	Mean Motion ☽.				Anomaly.				Motion ☊.			
	S.	°	′	″	S.	°	′	″	°	′	″
1	5	4	20	38	4	20	51	49	6	24	27
2	5	17	31	13	5	3	55	43	6	27	38
3	6	0	41	48	5	16	59	37	6	30	48
4	6	13	52	23	6	0	3	31	6	33	59
5	6	27	2	59	6	13	7	25	6	37	10
6	7	10	13	34	6	26	11	19	6	40	20
7	7	23	24	9	7	9	15	13	6	43	31
8	8	6	34	44	7	22	19	7	6	46	42
9	8	19	45	19	8	5	23	1	6	49	52
10	9	2	55	54	8	18	26	55	6	53	3
11	9	16	6	29	9	1	30	49	6	56	14
12	9	29	17	4	9	14	34	42	6	59	24
13	10	12	27	39	9	27	38	36	7	2	35
14	10	25	38	14	10	10	42	30	7	5	46
15	11	8	48	49	10	23	46	24	7	8	56
16	11	21	59	24	11	6	50	18	7	12	7
17	0	5	9	59	11	19	54	12	7	15	17
18	0	18	20	34	0	2	58	6	7	18	28
19	1	1	31	9	0	16	2	0	7	21	39
20	1	14	41	44	0	29	5	54	7	24	49
21	1	27	52	19	1	12	9	48	7	28	0
22	2	11	2	54	1	25	13	42	7	31	11
23	2	24	13	29	2	8	17	36	7	34	21
24	3	7	24	4	2	21	21	30	7	37	32
25	3	20	34	39	3	4	25	24	7	40	43
26	4	3	45	14	3	17	29	18	7	43	53
27	4	16	55	49	4	0	33	12	7	47	4
28	5	0	6	24	4	13	37	6	7	50	14
29	5	13	16	59	4	26	41	0	7	53	25
30	5	26	27	34	5	9	44	54	7	56	36
31	6	9	38	9	5	22	48	48	7	59	46

TABLE III. *The* MOON's MEAN MOTIONS *for* MONTHS *and* DAYS.

Days.	June.											
	Mean Motion ☽.				Anomaly.				Motion ☊.			
	S.	°	′	″	S.	°	′	″	°	′	″	
1	6	22	48	44	6	5	52	42	8	2	57	
2	7	5	59	19	6	18	56	36	8	5	8	
3	7	19	9	54	7	2	0	30	8	9	18	
4	8	2	20	29	7	15	4	24	8	12	29	
5	8	15	31	4	7	28	8	17	8	15	40	
6	8	28	41	39	8	11	12	11	8	18	50	
7	9	11	52	14	8	24	16	5	8	22	1	
8	9	25	2	49	9	7	19	59	8	25	11	
9	10	8	13	25	9	20	23	53	8	28	22	
10	10	21	24	0	10	3	27	47	8	31	33	
11	11	4	34	35	10	16	31	41	8	34	43	
12	11	17	45	10	10	29	35	35	8	37	54	
13	0	0	55	45	11	12	39	29	8	41	5	
14	0	14	6	20	11	25	43	23	8	44	15	
15	0	27	16	55	0	8	47	17	8	47	26	
16	1	10	27	30	0	21	51	11	8	50	37	
17	1	23	38	5	1	4	55	5	8	53	47	
18	2	6	48	40	1	17	58	59	8	56	58	
19	2	19	59	15	2	1	2	53	9	0	8	
20	3	3	9	50	2	14	6	47	9	3	19	
21	3	16	20	25	2	27	10	41	9	6	30	
22	3	29	31	0	3	10	14	35	9	9	40	
23	4	12	41	35	3	23	18	29	9	12	51	
24	4	25	52	10	4	6	22	23	9	16	2	
25	5	9	2	45	4	19	26	17	9	19	12	
26	5	22	13	20	5	2	30	11	9	22	23	
27	6	5	23	55	5	15	34	5	9	25	34	
28	6	18	34	30	5	28	37	59	9	28	44	
29	7	1	45	5	6	11	41	52	9	31	55	
30	7	14	55	40	6	24	45	46	9	35	6	

TABLE III. *The* MOON'S MEAN MOTIONS *for* MONTHS *and* DAYS.

Days.	July.											
	Mean Motion ☽.				Anomaly.				Motion ☊.			
	S.	°	′	″	S.	°	′	″	°	′	″
1	7	28	6	15	7	7	49	40	9	38	16
2	8	11	16	50	7	20	53	34	9	41	27
3	8	24	27	25	8	3	57	28	9	44	37
4	9	7	38	0	8	17	1	22	9	47	48
5	9	20	48	35	9	0	5	16	9	50	59
6	10	3	59	10	9	13	9	10	9	54	9
7	10	17	9	45	9	26	13	4	9	57	20
8	11	0	20	20	10	9	16	58	10	0	31
9	11	13	30	55	10	22	20	52	10	3	41
10	11	26	41	30	11	5	24	46	10	6	52
11	0	9	52	5	11	18	28	40	10	10	3
12	0	23	2	40	0	1	32	34	10	13	13
13	1	6	13	15	0	14	36	28	10	16	24
14	1	19	23	51	0	27	40	21	10	19	34
15	2	2	34	26	1	10	44	16	10	22	45
16	2	15	45	1	1	23	48	10	10	25	56
17	2	28	55	36	2	6	52	4	10	29	6
18	3	12	6	11	2	19	55	58	10	32	17
19	3	25	16	46	3	2	59	52	10	35	28
20	4	8	27	21	3	16	3	46	10	38	38
21	4	21	37	56	3	29	7	40	10	41	49
22	5	4	48	31	4	12	11	34	10	45	0
23	5	17	59	6	4	25	15	27	10	48	10
24	6	1	9	41	5	8	19	21	10	51	21
25	6	14	20	16	5	21	23	15	10	54	32
26	6	27	30	51	6	4	27	9	10	57	42
27	7	10	41	26	6	17	31	3	11	0	53
28	7	23	52	1	7	0	34	57	11	4	3
29	8	7	2	36	7	13	38	51	11	7	14
30	8	20	13	11	7	26	42	45	11	10	25
31	9	3	23	46	8	9	46	39	11	13	35

TABLE III. *The* MOON's MEAN MOTIONS *for* MONTHS *and* DAYS.

Days.	Auguſt.											
	Mean Motion ☽.				Anomaly.				Motion ☊.			
	S.	°	′	″	S.	°	′	″	°	′	″	
1	9	16	34	21	8	22	50	33	11	16	46	
2	9	29	44	56	9	5	54	27	11	19	57	
3	10	12	55	31	9	18	58	21	11	23	7	
4	10	26	6	6	10	2	2	15	11	26	18	
5	11	9	16	41	10	15	6	9	11	29	29	
6	11	22	27	16	10	28	10	3	11	32	39	
7	0	5	37	51	11	11	13	57	11	35	50	
8	0	18	48	26	11	24	17	51	11	39	0	
9	1	1	59	1	0	7	21	45	11	42	11	
10	1	15	9	36	0	20	25	39	11	45	22	
11	1	28	20	11	1	3	29	33	11	48	32	
12	2	11	30	46	1	16	33	27	11	51	43	
13	2	24	41	21	1	29	37	21	11	54	54	
14	3	7	51	56	2	12	41	15	11	58	4	
15	3	21	2	31	2	25	45	9	12	1	15	
16	4	4	13	6	3	8	49	3	12	4	26	
17	4	17	23	41	3	21	52	56	12	7	36	
18	5	0	34	17	4	4	56	50	12	10	47	
19	5	13	44	52	4	18	0	44	12	13	57	
20	5	26	55	27	5	1	4	38	12	17	8	
21	6	10	6	2	5	14	8	32	12	20	19	
22	6	23	16	37	5	27	12	26	12	23	29	
23	7	6	27	12	6	10	16	20	12	26	40	
24	7	19	37	47	6	23	20	14	12	29	51	
25	8	2	48	22	7	6	24	8	12	33	1	
26	8	15	58	57	7	19	28	2	12	36	12	
27	8	29	9	32	8	2	31	56	12	39	23	
28	9	12	20	7	8	15	35	50	12	42	33	
29	9	25	30	42	8	28	39	44	12	45	44	
30	10	8	41	17	9	11	43	38	12	48	54	
31	10	21	51	52	9	24	47	32	12	52	5	

TABLE III. *The Moon's Mean Motions for Months and Days.*

Days.	September.										
	Mean Motion ☽.				Anomaly.				Motion ☊.		
	S.	°	′	″	S.	°	′	″	°	′	″
1	11	5	2	27	10	7	51	26	12	55	16
2	11	18	13	2	10	20	55	20	12	58	26
3	0	1	23	37	11	3	59	14	13	1	37
4	0	14	34	12	11	17	3	8	13	4	48
5	0	27	44	47	0	0	7	2	13	7	58
6	1	10	55	22	0	13	10	56	13	11	9
7	1	24	5	57	0	26	14	50	13	14	20
8	2	7	16	32	1	9	18	44	13	17	30
9	2	20	27	7	1	22	22	38	13	20	41
10	3	3	37	42	2	5	26	31	13	23	52
11	3	16	48	17	2	18	30	26	13	27	12
12	3	29	58	52	3	1	34	19	13	30	13
13	4	13	9	27	3	14	38	13	13	33	23
14	4	26	20	2	3	27	42	7	13	36	34
15	5	9	30	37	4	10	46	1	13	39	45
16	5	22	41	12	4	23	49	55	13	42	55
17	6	5	51	47	5	6	53	49	13	46	6
18	6	19	2	22	5	19	57	43	13	49	17
19	7	2	12	57	6	3	1	37	13	52	27
20	7	15	23	32	6	16	5	31	13	55	38
21	7	28	34	7	6	29	9	25	13	58	49
22	8	11	44	43	7	12	13	19	14	1	59
23	8	24	55	18	7	25	17	13	14	5	10
24	9	8	5	53	8	8	21	7	14	8	20
25	9	21	16	28	8	21	25	1	14	11	31
26	10	4	27	3	9	4	28	55	14	14	42
27	10	17	37	38	9	17	32	49	14	17	52
28	11	0	48	13	10	0	36	43	14	21	3
29	11	13	58	48	10	13	40	37	14	24	14
30	11	27	9	23	10	26	44	31	14	27	24

TABLE III. *The* MOON's MEAN MOTIONS *for* MONTHS *and* DAYS.

Days	October.											
	Mean Motion ☽.				Anomaly.				Motion ☊.			
	S.	°	′	″	S.	°	′	″	°	′	″	
1	0	10	19	58	11	9	48	25	14	30	35	
2	0	23	30	33	11	22	52	19	14	33	46	
3	1	6	41	8	10	5	56	13	14	36	56	
4	1	19	51	43	10	19	0	6	14	40	7	
5	2	3	2	18	11	2	4	0	14	43	17	
6	2	16	12	53	11	15	7	54	14	46	28	
7	2	29	23	28	11	28	11	48	14	49	39	
8	3	12	34	3	12	11	15	42	14	52	49	
9	3	25	44	38	12	24	19	36	14	56	0	
10	4	8	55	13	13	7	23	30	14	59	11	
11	4	22	5	48	13	20	27	24	15	2	21	
12	5	5	16	23	14	3	31	18	15	5	32	
13	5	18	26	58	14	16	35	12	15	8	43	
14	6	1	37	33	14	29	39	6	15	11	53	
15	6	14	48	8	15	12	43	0	15	15	4	
16	6	27	58	43	15	25	46	54	15	18	15	
17	7	11	9	18	16	8	50	48	15	21	25	
18	7	24	19	53	16	21	54	42	15	24	36	
19	8	7	30	28	17	4	58	36	15	27	46	
20	8	20	41	3	17	18	2	30	15	30	57	
21	9	3	51	38	18	1	6	24	15	34	8	
22	9	17	2	13	18	14	10	18	15	37	18	
23	10	0	12	48	18	27	14	12	15	40	29	
24	10	13	23	23	19	10	18	6	15	43	40	
25	10	26	33	58	19	23	22	0	15	46	50	
26	11	9	44	33	20	6	25	54	15	50	1	
27	11	22	55	8	20	19	29	48	15	53	12	
28	0	6	5	44	21	2	33	41	15	56	22	
29	0	19	16	19	21	15	37	35	15	59	33	
30	1	2	26	54	21	28	41	29	16	2	43	
31	1	15	37	29	22	11	45	23	16	5	54	

TABLE III. *The Moon's Mean Motions for Months and Days.*

Days.	November.										
	Mean Motion ☽.				Anomaly.				Motion ☊.		
	S.	°	′	″	S.	°	′	″	°	′	″
1	1	28	48	4	0	24	49	17	16	9	5
2	2	11	58	39	1	7	53	11	16	12	15
3	2	25	9	14	1	20	57	5	16	15	26
4	3	8	19	49	2	4	0	59	16	18	37
5	3	21	30	24	2	17	4	53	16	21	47
6	4	4	40	59	3	0	8	47	16	24	58
7	4	17	51	34	3	13	12	41	16	28	9
8	5	1	2	9	3	26	16	35	16	31	19
9	5	14	12	44	4	9	20	29	16	34	30
10	5	27	23	19	4	22	24	23	16	37	40
11	6	10	33	54	5	5	28	17	16	40	51
12	6	23	44	29	5	18	32	11	16	44	2
13	7	6	55	4	6	1	36	5	16	47	12
14	7	20	5	39	6	14	39	59	16	50	23
15	8	3	16	14	6	27	43	53	16	53	34
16	8	16	26	49	7	10	47	47	16	56	44
17	8	29	37	24	7	23	51	41	16	59	55
18	9	12	47	59	8	6	55	35	17	3	6
19	9	25	58	34	8	19	59	29	17	6	16
20	10	9	9	9	9	3	3	23	17	9	27
21	10	22	19	44	9	16	7	16	17	12	38
22	11	5	30	19	9	29	11	10	17	15	48
23	11	18	40	54	10	12	15	4	17	18	59
24	0	1	51	29	10	25	18	58	17	22	9
25	0	15	2	4	11	8	22	52	17	25	20
26	0	28	12	39	11	21	26	46	17	28	31
27	1	11	23	14	0	4	30	40	17	31	41
28	1	24	33	49	0	17	34	34	17	34	52
29	2	7	44	24	1	0	38	28	17	38	3
30	2	20	54	59	1	13	42	22	17	41	13

TABLE III. *The Moon's Mean Motions for Months and Days.*

Days.	December.											
	Mean Motion ☽.				Anomaly.				Motion ☊.			
	S.	°	′	″	S.	°	′	″	°	′	″
1	3	4	5	34	1	26	46	16	17	44	24
2	3	17	16	10	2	9	50	10	17	47	35
3	4	0	26	45	2	22	54	4	17	50	45
4	4	13	37	20	3	5	57	58	17	53	56
5	4	26	47	55	3	19	1	52	17	57	6
6	5	9	58	30	4	2	5	46	18	0	17
7	5	23	9	5	4	15	9	40	18	3	28
8	6	6	19	40	4	28	13	34	18	6	38
9	6	19	30	15	5	11	17	28	18	9	49
10	7	2	40	50	5	24	21	22	18	13	0
11	7	15	51	25	6	7	25	16	18	16	10
12	7	29	2	0	6	20	29	10	18	19	21
13	8	12	12	35	7	3	33	4	18	22	32
14	8	25	23	10	7	16	36	58	18	25	42
15	9	8	33	45	7	29	40	51	18	28	53
16	9	21	44	20	8	12	44	45	18	32	3
17	10	4	54	55	8	25	48	39	18	35	14
18	10	18	5	30	9	8	52	33	18	38	25
19	11	1	16	5	9	21	56	27	18	41	35
20	11	14	26	40	10	5	0	21	18	44	46
21	11	27	37	15	10	18	4	15	18	47	56
22	0	10	47	50	11	1	8	9	18	51	7
23	0	23	58	25	11	14	12	3	18	54	18
24	1	7	9	0	11	27	15	57	18	57	29
25	1	20	19	35	0	10	19	51	19	0	39
26	2	3	30	10	0	23	23	45	19	3	50
27	2	16	40	45	1	6	27	39	19	7	0
28	2	29	51	20	1	19	31	33	19	10	11
29	3	13	1	55	2	2	35	27	19	13	22
30	3	26	12	30	2	15	39	21	19	16	32
31	4	9	23	5	2	28	43	15	19	19	43

TABLE IV. *The Moon's Mean Motions for Hours, Minutes, and Seconds.*

H.	M. Mot. ☽ ° ′ ″	Anomaly. ° ′ ″	Mot. ☊ ′ ″		M. Mot. ☽ ′ ″	Anomaly. ′ ″	Mo. ☊ ″
1	0 32 56	0 32 39	0 8	31	17 1 10	16 52 32	4 6
2	1 5 53	1 5 20	0 16	32	17 34 7	17 25 13	4 14
3	1 38 49	1 37 59	0 24	33	18 7 3	17 58 0	4 22
4	2 11 46	2 10 39	0 32	34	18 40 0	18 30 31	4 30
5	2 44 42	2 43 18	0 40	35	19 12 55	19 3 12	4 37
6	3 17 39	3 15 59	0 48	36	19 45 53	19 35 50	4 47
7	3 50 35	3 48 38	0 56	37	20 18 48	20 8 30	4 54
8	4 23 32	4 21 18	1 4	38	20 51 47	20 41 10	4 54
9	4 56 28	4 53 58	1 12	39	21 24 41	21 13 49	5 1
10	5 29 25	5 26 38	1 19	40	21 57 37	21 46 30	5 12
11	6 2 21	5 59 17	1 27	41	22 30 36	22 19 12	5 25
12	6 35 18	6 31 57	1 35	42	23 3 30	22 51 48	5 31
13	7 8 14	7 4 37	1 43	43	23 36 30	23 24 30	5 42
14	7 41 10	7 37 16	1 51	44	24 9 24	23 57 6	5 50
15	8 14 7	8 9 56	1 59	45	24 42 19	24 29 48	6 0
16	8 47 3	8 42 36	2 7	46	25 15 18	25 2 30	6 6
17	9 20 0	9 15 16	2 15	47	25 48 12	25 35 6	6 13
18	9 52 56	9 47 55	2 23	48	26 21 12	26 7 48	6 23
19	10 25 53	10 20 35	2 31	49	26 54 6	26 40 30	6 30
20	10 58 49	10 53 15	2 39	50	27 27 0	27 13 6	6 36
21	11 31 46	11 25 55	2 47	51	28 0 0	27 45 48	6 48
22	12 4 42	11 58 34	2 55	52	28 32 55	28 18 30	6 54
23	12 37 39	12 31 14	3 3	53	29 5 54	28 51 6	7 0
24	13 10 35	13 3 54	3 11	54	29 38 48	29 23 48	7 6
25	13 43 32	13 36 34	3 19	55	30 11 48	29 56 24	7 18
26	14 16 28	14 9 13	3 26	56	30 44 42	30 29 6	7 24
27	14 49 24	14 41 53	3 34	57	31 17 36	31 1 48	7 30
28	15 22 21	15 14 33	3 42	58	31 50 36	31 34 24	7 48
29	15 55 17	15 47 13	3 50	59	32 23 30	32 7 6	7 48
30	16 28 14	16 19 52	3 58	60	32 56 39	32 39 48	7 56

TABLES OF THE MOON'S EQUATIONS.

I. *Annual Equation of the Moon's Node.*

Argument. Sun's Mean Anomaly.

S.	+ 0	+ 1	+ 2	+ 3	+ 4	+ 5	S.
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
0	0 0	4 30	7 52	9 12	8 4	4 42	30
5	0 47	5 10	8 15	9 11	7 38	3 58	25
10	1 34	5 48	8 34	9 6	7 9	3 13	20
15	2 19	6 23	8 49	8 56	6 37	2 26	15
20	3 4	6 56	9 1	8 43	6 1	1 38	10
25	3 48	7 26	9 8	8 25	5 23	0 49	5
30	4 30	7 52	9 12	8 4	4 42	0 0	0
S.	— 11	— 10	— 9	— 8	— 7	— 6	S.

Annual Equation of Moon's Mean Anomaly.

Argument. Sun's Mean Anomaly.

S.	+ 0	+ 1	+ 2	+ 3	+ 4	+ 5	S.
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
0	0 0	10 37	18 33	21 42	19 1	11 5	30
5	1 51	12 11	19 27	21 39	18 1	9 23	25
10	3 40	13 41	20 13	21 27	16 53	7 36	20
15	5 29	15 4	20 49	21 5	15 37	5 45	15
20	7 15	16 21	21 16	20 34	14 13	3 52	10
25	8 58	17 31	21 34	19 52	12 42	1 56	5
30	10 37	18 33	21 42	19 1	11 5	0 0	0
S.	— 11	— 10	— 9	— 8	— 7	— 6	S.

I. *For the Moon's Longitude.*

Argument. Sun's Mean Anomaly.

S.	+ 0	+ 1	+ 2	+ 3	+ 4	+ 5	S.
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
0	0 0	5 27	9 31	11 9	9 47	5 42	30
5	0 57	6 15	9 59	11 8	9 16	4 49	25
10	1 53	7 1	10 23	11 1	8 41	3 54	20
15	2 49	7 44	10 41	10 50	8 2	2 58	15
20	3 43	8 23	10 55	10 34	7 19	1 59	10
25	4 36	8 59	11 4	10 13	6 32	1 0	5
30	5 27	9 31	11 9	9 47	5 42	0 0	0
S.	— 11	— 10	— 9	— 8	— 7	— 6	S.

II. *For the Moon's Longitude.*

Arg. II. 2 ☽ *à* ☉ + Arg. I.

S.	— 0	— 1	— 2	S.
S.	+ 6	+ 7	+ 8	S.
°	″	″	″	°
0	0	28	48	30
5	5	32	51	25
10	10	36	52	20
15	14	39	54	15
20	19	43	55	10
25	24	46	56	5
30	28	48	56	0
S.	+ 11	+ 10	+ 9	S.
S.	— 5	— 4	— 3	S.

III. *For the Moon's Longitude.*

Arg. III. 2 ☽ *à* ☉ — Arg. I.

S.	— 0	— 1	— 2	S.
S.	+ 6	+ 7	+ 8	S.
°	′ ″	′ ″	′ ″	°
0	0 0	0 38	1 5	30
5	0 7	0 43	1 8	25
10	0 13	0 48	1 11	20
15	0 19	0 53	1 13	15
20	0 26	0 58	1 14	10
25	0 32	1 2	1 15	5
30	0 38	1 5	1 15	0
S.	+ 11	+ 10	+ 9	S.
S.	— 5	— 4	— 3	S.

IV. *For the Moon's Longitude.*

Arg. IV. 2 ☽ *à* ☉ + ☽'s M. Anom.

S.	+ 0	+ 1	+ 2	S.
S.	— 6	— 7	— 8	S.
°	″	″	″	°
0	0	29	50	30
5	5	33	52	25
10	10	37	54	20
15	15	41	56	15
20	20	44	57	10
25	24	47	57	5
30	29	50	58	0
S.	— 11	— 10	— 9	S.
S.	+ 5	+ 4	+ 3	S.

V. *For the Moon's Longitude.* *Evection.*

Argument V. 2 ☽ *a* ☉ — ☽'s Mean Anomaly.

S.	— 0	— 1	— 2	— 3	— 4	— 5	S.
°	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	°
0	0 0 0	0 39 44	1 9 11	1 20 28	1 10 12	0 40 45	30
1	0 1 23	0 40 56	1 9 53	1 20 29	1 9 30	0 39 31	29
2	0 2 46	0 42 7	1 10 34	1 20 28	1 8 46	0 38 16	28
3	0 4 9	0 43 18	1 11 14	1 20 25	1 8 1	0 37 0	27
4	0 5 32	0 44 27	1 11 52	1 20 21	1 7 15	0 35 45	26
5	0 6 55	0 45 36	1 12 29	1 20 16	1 6 28	0 34 27	25
6	0 8 17	2 46 45	1 13 5	1 20 9	1 5 40	0 33 10	24
7	0 9 40	0 47 52	1 13 39	1 20 1	1 4 50	0 31 52	23
8	0 11 2	0 48 59	1 14 12	1 19 51	1 3 59	0 30 33	22
9	0 12 24	0 50 4	1 14 44	1 19 40	1 3 7	0 29 14	21
10	0 13 46	0 51 9	1 15 15	1 19 27	1 2 13	0 27 54	20
11	0 15 8	0 52 13	1 15 44	1 19 13	1 1 19	0 26 34	19
12	0 16 30	0 53 16	1 16 11	1 18 57	1 0 23	0 25 13	18
13	0 17 51	0 54 18	1 16 38	1 18 40	0 59 26	0 23 51	17
14	0 19 12	0 55 19	1 17 3	1 18 21	0 58 28	0 22 29	16
15	0 20 32	0 56 19	1 17 26	1 18 1	0 57 29	0 21 7	15
16	0 21 52	0 57 18	1 17 48	1 17 40	0 56 29	0 19 44	14
17	0 23 12	0 58 16	1 18 9	1 17 17	0 55 28	0 18 22	13
18	0 24 31	0 59 13	1 18 29	1 16 53	0 54 26	0 16 58	12
19	0 25 50	1 0 9	1 18 47	1 16 27	0 53 22	0 15 34	11
20	0 27 9	1 1 4	1 19 3	1 16 0	0 52 18	0 14 10	10
21	0 28 27	1 1 58	1 19 18	1 15 31	0 51 13	0 12 46	9
22	0 29 44	1 2 51	1 19 32	1 15 1	0 50 7	0 11 22	8
23	0 31 1	1 3 42	1 19 44	1 14 30	0 49 0	0 9 57	7
24	0 32 18	1 4 33	1 19 55	1 13 57	0 47 51	0 8 32	6
25	0 33 34	1 5 22	1 20 4	1 13 23	0 46 42	0 7 7	5
26	0 34 49	1 6 10	1 20 12	1 12 47	0 45 33	0 5 42	4
27	0 36 4	1 6 57	1 20 18	1 12 10	0 44 22	0 4 16	3
28	0 37 18	1 7 43	1 20 23	1 11 32	0 43 10	0 2 51	2
29	0 38 31	1 8 28	1 20 26	1 10 53	0 41 58	0 1 25	1
30	0 39 44	1 9 11	1 20 28	1 10 12	0 40 45	0 0 0	0
S.	+ 11	+ 10	+ 9	+ 8	+ 7	+ 6	S.

VI. *For the ☽'s Longitude.*

Argument.

Arg. V. + Arg. I.

S.	+ 0	+ 1	+ 2	S.
S.	— 6	— 7	— 8	S.
°	′ ″	′ ″	′ ″	°
0	0 0	1 2	1 47	30
5	0 11	1 11	1 52	25
10	0 21	1 19	1 56	20
15	0 32	1 27	1 59	15
20	0 42	1 35	2 2	10
25	0 52	1 41	2 3	5
30	1 2	1 47	2 3	0
S.	—11	—10	— 9	S.
S.	+ 5	+ 4	+ 3	S.

VII. *For the ☽'s Longitude.*

Argument.

Arg. V. — Arg. I.

S.	+ 0	+ 1	+ 2	S.
S.	— 6	— 7	— 8	S.
°	″	″	″	°
0	0	23	40	30
5	4	27	42	25
10	8	30	44	20
15	12	33	45	15
20	16	36	46	10
25	20	38	46	5
30	23	40	47	0
S.	—11	—10	— 9	S.
S.	+ 5	+ 4	+ 3	S.

VIII. *For the ☽'s Longitude.*

Argument.

☽'s Mean Anom. — Arg. I.

S.	+ 0	+ 1	+ 2	S.
S.	— 6	— 7	— 8	S.
°	″	″	″	°
0	0	21	36	30
5	4	24	38	25
10	7	27	40	20
15	11	30	41	15
20	14	32	41	10
25	18	34	42	5
30	21	36	42	0
S.	—11	—10	— 9	S.
S.	+ 5	+ 4	+ 3	S.

IX. *For the Moon's Longitude.*

Argument IX. Mean Dist. ☽ *à* ☉ — ☽'s Mean Anomaly.

S.	— 0	— 1	∓ 2	+ 3	+ 4	+ 5	S.
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
0	0 0	0 38	0 30	0 23	1 9	1 1	30
5	8	41	23	33	1 12	0 54	25
10	16	42	16	42	1 14	0 45	20
15	23	41	7	51	1 13	0 35	15
20	29	39	+ 3	58	1 11	23	10
25	34	35	13	1 5	1 7	12	5
30	38	30	23	1 9	1 1	0 0	0
S.	+ 11	+ 10	∓ 9	— 8	— 7	— 6	S.

X. *For the Moon's Longitude,*

Argument X.

Mean Long. ☊ — True Long. ☉.

S.	+ 0	+ 1	+ 2	S.
S.	+ 6	+ 7	+ 8	S.
°	″	′ ″	″	°
0	0	0 52	52	30
5	10	0 57	46	25
10	21	0 59	39	20
15	30	1 0	30	15
20	39	1 0	21	10
25	46	0 57	10	5
30	52	0 52	0	0
S.	—11	— 10	— 9	S.
S.	— 5	— 4	— 3	S.

XI. *For the Moon's Longitude. Equation of the Centre.*

Argument XI. Moon's Correct Anomaly.

S.	— 0	— 1	— 2	S.
°	° ′ ″	° ′ ″	° ′ ″	°
0	0 0 0	2 58 30	5 16 21	30
1	0 6 11	3 3 59	5 19 48	29
2	0 12 22	3 9 24	5 23 10	28
3	0 18 32	3 14 46	5 26 26	27
4	0 24 42	3 20 5	5 29 38	26
5	0 30 52	3 25 22	5 32 43	25
6	0 37 2	3 30 35	5 35 43	24
7	0 43 11	3 35 45	5 38 38	23
8	0 49 19	3 40 51	5 41 27	22
9	0 55 26	3 45 54	5 44 11	21
10	1 1 33	3 50 54	5 46 48	20
11	1 7 39	3 55 50	5 49 20	19
12	1 13 44	4 0 42	5 51 45	18
13	1 19 47	4 5 30	5 54 5	17
14	1 25 50	4 10 15	5 56 19	16
15	1 31 51	4 14 56	5 58 27	15
16	1 37 51	4 19 33	6 0 28	14
17	1 43 49	4 24 5	6 2 24	13
18	1 49 45	4 28 34	6 4 13	12
19	1 55 41	4 32 58	6 5 56	11
20	2 1 34	4 37 18	6 7 32	10
21	2 7 25	4 41 33	6 9 2	9
22	2 13 15	4 45 44	6 10 26	8
23	2 19 2	4 49 50	6 11 43	7
24	2 24 48	4 53 52	6 12 54	6
25	2 30 31	4 57 49	6 13 58	5
26	2 36 12	5 1 41	6 14 55	4
27	2 41 50	5 5 29	6 15 46	3
28	2 47 26	5 9 11	6 16 30	2
29	2 53 0	5 12 49	6 17 7	1
30	2 58 30	5 16 21	6 17 38	0
S.	+ 11	+ 10	+ 9	S.

XI. *For the Moon's Longitude. Equation of the Centre.*

Argument XI. Moon's Correct Anomaly.

S.	— 3	— 4	— 5	S.
°	° ′ ″	° ′ ″	° ′ ″	°
0	6 17 38	5 38 46	3 20 56	30
1	6 18 2	5 35 41	3 14 57	29
2	6 18 18	5 32 28	3 8 54	28
3	6 18 28	5 29 8	3 2 47	27
4	6 18 32	5 25 42	2 56 36	26
5	6 18 28	5 22 10	2 50 21	25
6	6 18 17	5 18 30	2 44 2	24
7	6 17 59	5 14 44	2 37 40	23
8	6 17 34	5 10 52	2 31 14	22
9	6 17 3	5 6 53	2 24 45	21
10	6 16 24	5 2 48	2 18 13	20
11	6 15 38	4 58 37	2 11 37	19
12	6 14 45	4 54 19	2 4 59	18
13	6 13 45	4 49 55	1 58 18	17
14	6 12 38	4 45 25	1 51 34	16
15	6 11 24	4 40 50	1 44 48	15
16	6 10 3	4 36 8	1 37 59	14
17	6 8 34	4 31 20	1 31 8	13
18	6 6 59	4 26 27	1 24 16	12
19	6 5 16	4 21 29	1 17 21	11
20	6 3 27	4 16 24	1 10 25	10
21	6 1 30	4 11 14	1 3 27	9
22	5 59 27	4 5 59	0 56 27	8
23	5 57 16	4 0 38	0 49 27	7
24	5 54 58	3 55 13	0 42 25	6
25	5 52 34	3 49 42	0 35 22	5
26	5 50 2	3 44 6	0 28 19	4
27	5 47 23	3 38 26	0 21 15	3
28	5 44 38	3 32 40	0 14 10	2
29	5 41 46	3 26 51	0 7 5	1
30	5 38 46	3 20 56	0 0 0	0
S.	+ 8	+ 7	+ 6	S.

XII. *For the Moon's Longitude. Variation.*

Argument XII. ☽'s equated Long. — ☉'s true Long.

S.	+ 0	+ 1	+ 2	— 3	— 4	— 5	S.
☌	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
0	0 0	30 9	29 6	2 2	32 28	31 55	30
1	1 14	30 43	28 26	3 16	33 3	31 15	29
2	2 27	31 15	27 44	4 30	33 36	30 33	28
3	3 40	31 44	27 0	5 43	34 6	29 48	27
4	4 53	32 11	26 13	6 57	34 35	29 2	26
5	6 6	32 36	25 25	8 10	35 1	28 13	25
6	7 18	32 58	24 35	9 22	35 24	27 22	24
7	8 30	33 18	23 43	10 34	35 45	26 29	23
8	9 41	33 35	22 49	11 46	36 3	25 35	22
9	10 51	33 49	21 53	12 56	36 19	24 38	21
10	12 0	34 1	20 56	14 6	36 32	23 40	20
11	13 9	34 11	19 57	15 15	36 43	22 40	19
12	14 16	34 18	18 57	16 23	36 51	21 39	18
13	15 23	34 22	17 55	17 29	36 57	20 35	17
14	16 28	34 23	16 52	18 35	36 59	19 30	16
15	17 31	34 22	15 47	19 39	37 0	18 24	15
16	18 34	34 19	14 41	20 42	36 57	17 17	14
17	19 35	34 13	13 34	21 44	36 53	16 8	13
18	20 35	34 4	12 26	22 44	36 45	14 58	12
19	21 33	33 53	11 17	23 43	36 35	13 47	11
20	22 30	33 39	10 8	24 40	36 22	12 36	10
21	23 24	33 23	8 57	25 35	36 6	11 23	9
22	24 17	33 4	7 45	26 29	35 48	10 9	8
23	25 8	32 43	6 34	27 21	35 28	8 54	7
24	25 57	32 19	5 21	28 10	35 5	7 39	6
25	26 45	31 53	4 8	28 59	34 39	6 24	5
26	27 30	31 24	2 54	29 45	34 11	5 7	4
27	28 13	30 53	1 41	30 29	33 41	3 51	3
28	28 54	30 19	+ 0 27	31 10	33 8	2 34	2
29	29 32	29 44	— 0 47	31 50	32 32	1 17	1
30	30 9	29 6	— 2 2	32 28	31 55	0 0	0
S.	— 11	— 10	= 9	+ 8	+ 7	+ 6	S.

XIII. *For the ☽'s Longitude.* XIV. *For the ☽'s Long. Reduct.*

Argument XIII.

Doub. eq. dist. ☽ à ☊ — ☽ C. An.

S.	+ 0	+ 1	+ 2	S.
S.	— 6	— 7	— 8	S.
°	′ ″	′ ″	′ ″	°
0	0 0	0 42	1 13	30
5	0 7	0 48	1 16	25
10	0 15	0 54	1 19	20
15	0 22	0 59	1 21	15
20	0 29	1 4	1 23	10
25	0 35	1 9	1 24	5
30	0 42	1 13	1 24	0
S.	— 11	— 10	— 9	S.
S.	+ 5	+ 4	+ 3	S.

Equation of the Equinoctial Points.

Argument.

Mean Longitude Moon's ☊.

S.	— 0	— 1	— 2	S.
S.	+ 6	+ 7	+ 8	S.
°	″	″	″	°
0	0	9	16	30
5	1	10	16	25
10	3	12	17	20
15	5	13	17	15
20	6	14	18	10
25	8	15	18	5
30	9	16	18	0
S.	+ 11	+ 10	+ 9	S.
S.	— 5	— 4	— 3	S.

Argument XIV.

Long. ☽ in Orb. — C. Lon. ☊.

S.	— 0	— 1	— 2	S.
S.	— 6	— 7	— 8	S.
°	′ ″	′ ″	′ ″	°
0	0 0	5 53	5 53	30
1	0 14	6 0	5 46	29
2	0 28	6 6	5 38	28
3	0 43	6 12	5 30	27
4	0 57	6 18	5 21	26
5	1 11	6 23	5 12	25
6	1 25	6 28	5 3	24
7	1 39	6 32	4 53	23
8	1 52	6 36	4 43	22
9	2 6	6 39	4 33	21
10	2 19	6 41	4 22	20
11	2 33	6 44	4 11	19
12	2 46	6 45	4 0	18
13	2 59	6 47	3 48	17
14	3 11	6 47	3 36	16
15	3 24	6 48	3 24	15
16	3 36	6 47	3 11	14
17	3 48	6 47	2 59	13
18	4 0	6 45	2 46	12
19	4 11	6 44	2 33	11
20	4 23	6 41	2 19	10
21	4 33	6 39	2 6	9
22	4 43	6 36	1 52	8
23	4 53	6 32	1 39	7
24	5 3	6 28	1 25	6
25	5 12	6 23	1 11	5
26	5 21	6 18	0 57	4
27	5 30	6 12	0 43	3
28	5 38	6 6	0 28	2
29	5 46	6 0	0 14	1
30	5 53	5 53	0 0	0
S.	+ 11	+ 10	+ 9	S.
S.	+ 5	+ 4	+ 3	S.

TABLES FOR FINDING THE MOON'S LATITUDE.

I. *For the Moon's Latitude.*

Argument I.

Long. ☽ in Orbit — Correct Long. ☊.

S.	+ 0	+ 1	+ 2	S.
S.	— 6	— 7	— 8	S.
°	° ′ ″	° ′ ″	° ′ ″	°
0	0 0 0	2 34 18	4 27 23	30
1	0 5 23	2 38 56	4 30 2	29
2	0 10 46	2 43 32	4 32 37	28
3	0 16 9	2 48 5	4 35 6	27
4	0 21 31	2 52 35	4 37 31	26
5	0 26 53	2 57 1	4 39 50	25
6	0 32 15	3 1 24	4 42 4	24
7	0 37 36	3 5 44	4 44 14	23
8	0 42 56	3 10 1	4 46 17	22
9	0 48 16	3 14 14	4 48 16	21
10	0 53 35	3 18 23	4 50 9	20
11	0 58 52	3 22 29	4 51 58	19
12	1 4 9	3 26 32	4 53 40	18
13	1 9 24	3 30 30	4 55 18	17
14	1 14 39	3 34 25	4 56 50	16
15	1 19 51	3 38 16	4 58 16	15
16	1 25 3	3 42 2	4 59 38	14
17	1 30 13	3 45 45	5 0 53	13
18	1 35 21	3 49 24	5 2 3	12
19	1 40 27	3 52 58	5 3 8	11
20	1 45 32	3 56 28	5 4 7	10
21	1 50 35	3 59 54	5 5 0	9
22	1 55 35	4 3 16	5 5 48	8
23	2 0 34	4 6 33	5 6 31	7
24	2 5 30	4 9 45	5 7 7	6
25	2 10 25	4 12 53	5 7 38	5
26	2 15 16	4 15 57	5 8 4	4
27	2 20 6	4 18 55	5 8 23	3
28	2 24 52	4 21 49	5 8 38	2
29	2 29 36	4 24 38	5 8 46	1
30	2 34 18	4 27 23	5 8 49	0
S.	— 11	— 10	— 9	S.
S.	+ 5	+ 4	+ 3	S.

II. *For the Moon's Latitude.*

Argument II.

Double Dist. ☽ in Orb. à ☉ — Arg. I.

S.	+ 0	+ 1	+ 2	S.
S.	— 6	— 7	— 8	S.
°	′ ″	′ ″	′ ″	°
0	0 0	4 24	7 38	30
1	0 9	4 32	7 42	29
2	0 18	4 40	7 46	28
3	0 28	4 48	7 51	27
4	0 37	4 55	7 55	26
5	0 46	5 3	7 59	25
6	0 55	5 11	8 3	24
7	1 4	5 18	8 6	23
8	1 14	5 25	8 10	22
9	1 23	5 32	8 13	21
10	1 32	5 40	8 16	20
11	1 41	5 47	8 20	19
12	1 50	5 54	8 22	18
13	1 59	6 0	8 25	17
14	2 8	6 7	8 28	16
15	2 17	6 14	8 30	15
16	2 26	6 20	8 33	14
17	2 34	6 26	8 35	13
18	2 43	6 33	8 37	12
19	2 52	6 39	8 39	11
20	3 1	6 45	8 40	10
21	3 9	6 51	8 42	9
22	3 18	6 56	8 43	8
23	3 26	7 2	8 44	7
24	3 35	7 7	8 45	6
25	3 43	7 13	8 46	5
26	3 52	7 18	8 47	4
27	4 0	7 23	8 48	3
28	4 8	7 28	8 48	2
29	4 16	7 33	8 48	1
30	4 24	7 38	8 48	0
S.	— 11	— 10	— 9	S.
S.	+ 5	+ 4	+ 3	S.

III. *For the Moon's Latitude.*

Argument.

Arg. I. — ☉ Mean Anom.

S.	— 0	— 1	— 2	S.
S.	+ 6	+ 7	+ 8	S.
°	″	″	″	°
0	0	9	15	30
10	3	11	16	20
20	6	13	17	10
30	9	15	18	0
S.	+ 11	+ 10	+ 9	S.
S.	— 5	— 4	— 3	S.

IV. *For the Moon's Latitude.*

Argument.

Arg. III. — ☽'s Mean An.

S.	— 0	— 1	— 2	S.
S.	+ 6	+ 7	+ 8	S.
°	″	″	″	°
0	0	13	22	30
10	4	16	24	20
20	9	19	25	10
30	13	22	25	0
S.	+ 11	+ 10	+ 9	S.
S.	— 5	— 4	— 3	S.

V. *For the Moon's Latitude.*

Argument.

Arg. IV. ☽'s Mean Anom.

S.	+ 0	+ 1	+ 2	S.
S.	— 6	— 7	— 8	S.
°	″	″	″	°
0	0	8	14	30
10	3	10	15	20
20	5	12	16	10
30	8	14	16	0
S.	— 11	— 10	— 9	S.
S.	+ 5	+ 4	+ 3	S.

For the MOON's EQUATORIAL PARALLAX.

I. Argument V. of Longitude, viz. 2 ☽ ☌ ☉ — ☽'s Mean Anomaly.

S.	— 0	— 1	— 2	+ 3	+ 4	+ 5	S.
°	″	″	″	″	″	″	°
0	37	32	19	0	18	32	30
5	37	30	16	3	21	34	25
10	36	28	13	6	24	35	20
15	36	26	10	9	26	36	15
20	35	24	7	13	29	37	10
25	34	21	3	16	31	37	5
30	32	19	0	18	32	38	0
S.	— 11	— 10	— 9	+ 8	+ 7	+ 6	S.

II. Argument XI. of Longitude, viz. correct Anomaly of ☽.

S.	+ 0	+ 1	+ 2	+ 3	+ 4	+ 5	S.
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
0	54 13	54 33	55 32	57 1	58 39	59 59	30
5	54 14	54 41	55 46	57 17	58 55	60 8	25
10	54 15	54 49	55 59	57 34	59 10	60 15	20
15	54 18	54 58	56 14	57 51	59 24	60 21	15
20	54 22	55 9	56 29	58 7	59 36	60 25	10
25	54 27	55 20	56 45	58 24	59 48	60 28	5
30	54 33	55 32	57 1	58 39	59 59	60 29	0
S.	+ 11	+ 10	+ 9	+ 8	+ 7	+ 6	S.

III. Argument XII. of Longitude, viz. ☽'s equated Longitude — ☉ true Longitude.

S.	+ 0	± 1	— 2	— 3	± 4	+ 5	S.
°	″	″	″	″	″	″	°
0	25	12	14	26	13	14	30
5	25	8	17	25	8	18	25
10	24	+ 3	20	24	— 4	21	20
15	22	— 1	23	22	+ 0	24	15
20	19	5	24	19	5	25	10
25	16	10	25	16	10	27	5
30	12	14	26	13	14	27	0
S.	+ 11	± 10	— 9	— 8	± 7	+ 6	S.

Table for reducing the Equatorial to the Horizontal Parallax in any Latitude; and also the Reduction of the given Latitude.

Given Lat.	Reduction of Parallax.			Reduction of Latitude
	′ 54	′ 57	′ 60	° ′
°	″	″	″	′ ″
6	0	0	0	3 6
12	1	1	1	6 4
18	1	1	2	8 57
24	2	2	3	11 6
30	4	4	4	12 56
36	5	5	5	14 12
42	6	7	7	14 51
48	8	8	9	14 51
54	9	10	10	14 12
60	10	11	12	12 56
66	12	12	13	12 6
72	13	13	14	8 56
78	13	14	15	6 4
84	14	15	16	3 6

The argument of this Table is the latitude of the place in the left hand column, and the equatorial parallax on the head; in the angle of meeting is the reduction of parallax; and in the same line in the right-hand column is the reduction of the latitude.

Table for finding the Moon's Diameter.

Argument. Equatorial Parallax

Equat. Par.		☽'s Diam.		Equat. Par.		☽'s Diam.	
′	″	′	″	′	″	′	″
54	0	29	26	58	0	31	37
54	10	29	31	58	10	31	42
54	20	29	37	58	20	31	47
54	30	29	42	58	30	31	53
54	40	29	48	58	40	31	58
54	50	29	53	58	50	32	4
55	0	29	58	59	0	32	9
55	10	30	4	59	10	32	15
55	20	30	9	59	20	32	20
55	30	30	15	59	30	32	26
55	40	30	20	59	40	32	31
55	50	30	26	59	50	32	36
56	0	30	31	60	0	32	42
56	10	30	37	60	10	32	47
56	20	30	42	60	20	32	53
56	30	30	47	60	30	32	58
56	40	30	53	60	40	33	4
56	50	30	58	60	50	33	9
57	0	31	4	61	0	33	15
57	10	31	9	61	10	33	20
57	20	31	15	61	20	33	26
57	30	31	20	61	30	33	31
57	40	31	26	61	40	33	36
57	50	31	31	61	50	33	42
58	0	31	37	62	0	33	47

TABLES FOR FINDING THE MOON'S HOURLY MOTION IN LONGITUDE AND LATITUDE.

I. *For the Moon's Hourly Motion in Longitude.*

Argument V. of Longitude, viz. 2 ☽ *à* ☉ — ☽'s Mean Anomaly.

S.	— 0	— 1	— 2	+ 3	+ 4	+ 5	S.
°	″	″	″	″	″	″	°
0	41	36	21	0	21	37	30
5	41	34	18	3	24	38	25
10	41	32	15	7	27	40	20
15	40	30	11	10	30	41	15
20	39	27	8	14	32	42	10
25	38	24	4	17	35	42	5
30	36	21	0	21	37	43	0
S.	— 11	— 10	— 9	+ 8	+ 7	+ 6	S.

II. *For the Moon's Hourly Motion in Longitude.*

Argument XI. of Longitude, viz. the correct Anomaly of the ☽.

S.	+ 0	+ 1	+ 2	+ 3	+ 4	+ 5	S.
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
0	29 35	29 57	31 2	32 42	34 36	36 10	30
5	29 35	30 5	31 17	33 0	34 54	36 21	25
10	29 37	30 15	31 32	33 19	35 11	36 30	20
15	29 40	30 25	31 49	33 39	35 28	36 38	15
20	29 45	30 36	32 6	33 58	35 43	36 43	10
25	29 50	30 49	32 23	34 17	35 57	36 46	5
30	29 57	31 2	32 42	34 36	36 10	36 48	0
S.	+ 11	+ 10	+ 9	+ 8	+ 7	+ 6	S.

III. *For the Moon's Hourly Motion in Longitude.*

Argument XII. of Long. viz. ☽'s equat. Long. — ☉ true Longitude.

S.	+ 0	± 1	— 2	— 3	∓ 4	+ 5	S.
°	″	″	″	″	″	″	°
0	40	19	21	40	20	21	30
5	39	13	26	39	13	27	25
10	37	+ 6	31	37	— 7	32	20
15	34	— 1	35	34	+ 0	36	15
20	30	8	38	30	7	39	10
25	25	15	39	25	14	41	5
30	19	21	40	20	21	42	0
S.	+ 11	± 10	— 9	— 8	∓ 7	+ 6	S.

I. *For the Moon's Hourly Motion in Latitude.*

Argument I. of Lat.

S.	+ 0	+ 1	+ 2	S.
S.	— 6	— 7	— 8	S.
°	′ ″	′ ″	′ ″	°
0	2 58	2 34	1 29	30
5	2 57	2 26	1 15	25
10	2 55	2 16	1 1	20
15	2 52	2 6	0 46	15
20	2 47	1 54	0 31	10
25	2 41	1 42	0 15	5
30	2 34	1 29	0 0	0
S.	+11	+10	+ 9	S.
S.	— 5	— 4	— 3	S.

II. *For the Moon's Hourly Motion in Latitude.*

Argument II. of Lat.

S.	+ 0	+ 1	+ 2	S.
S.	— 6	— 7	— 8	S.
°	″	″	″	°
0	4	4	2	30
5	4	3	2	25
10	4	3	1	20
15	4	3	1	15
20	4	3	1	10
25	4	2	0	5
30	4	2	0	0
S.	+11	+10	+ 9	S.
S.	— 5	— 4	— 3	S.

Angle of the visible Path of the Moon with the Ecliptic in Eclipses.

Argument. Long. ☽ in her Orbit — Long. ☊.

	o Signs 6.										
	Horary Motion of the Moon from the Sun.										
	′ 27	′ 28	′ 29	′ 30	′ 31	′ 32	′ 33	′ 34	′ 35	′ 36	
o	o ′	o ′	o ′	o ′	o ′	o ′	o ′	o ′	o ′	o ′	o
0	5 47	5 46	5 45	5 44	5 43	5 42	5 41	5 41	5 40	5 39	30
3	5 46	5 45	5 44	5 43	5 42	5 42	5 41	5 40	5 40	5 39	27
6	5 45	5 44	5 43	5 42	5 41	5 40	5 39	5 39	5 38	5 38	24
9	5 42	5 41	5 40	5 39	5 39	5 38	5 37	5 37	5 36	5 35	21
12	5 39	5 38	5 37	5 36	5 35	5 35	5 34	5 33	5 33	5 32	18
15	5 35	5 34	5 33	5 32	5 31	5 31	5 30	5 29	5 29	5 28	15
	11 Signs 5.										

Tables for finding the Right Ascension of the Moon, or any Star; its Longitude and Latitude being given: the Latitude not exceeding 6°.

Longitude { 0. S. with north latitude.
6. S. with south latitude.

	6°			5°			4°			3°			2°		1°		
°	°	′	″	°	′	″	°	′	″	°	′	″	′	″	′	″	°
0	2	23	49	1	59	44	1	35	43	1	11	45	47	49	23	54	30
1	2	23	54	1	59	47	1	35	45	1	11	46	47	50	23	54	29
2	2	23	57	1	59	49	1	35	46	1	11	46	47	50	23	54	28
3	2	23	58	1	59	50	1	35	46	1	11	45	47	49	23	53	27
4	2	23	58	1	59	49	1	35	44	1	11	43	47	47	23	52	26
5	2	23	56	1	59	46	1	35	41	1	11	41	47	44	23	51	25
6	2	23	52	1	59	42	1	35	37	1	11	38	47	41	23	50	24
7	2	23	46	1	59	36	1	35	32	1	11	34	47	38	23	48	23
8	2	23	38	1	59	29	1	35	25	1	11	29	47	34	23	46	22
9	2	23	28	1	59	20	1	35	17	1	11	22	47	30	23	43	21
10	2	23	17	1	59	9	1	35	8	1	11	14	47	25	23	40	20
11	2	23	3	1	58	57	1	34	58	1	11	6	47	19	23	37	19
12	2	22	48	1	58	43	1	34	47	1	10	57	47	13	23	34	18
13	2	22	31	1	58	28	1	34	34	1	10	47	47	6	23	30	17
14	2	22	12	1	58	12	1	34	20	1	10	36	46	58	23	26	16
15	2	21	51	1	57	54	1	34	5	1	10	24	46	50	23	22	15
16	2	21	28	1	57	34	1	33	48	1	10	11	46	41	23	18	14
17	2	21	3	1	57	12	1	33	30	1	9	58	46	32	23	13	13
18	2	20	36	1	56	48	1	33	11	1	9	42	46	22	23	8	12
19	2	20	6	1	56	23	1	32	50	1	9	26	46	11	23	2	11
20	2	19	34	1	55	56	1	32	29	1	8	9	45	59	22	56	10
21	2	19	0	1	55	27	1	32	5	1	8	51	45	46	22	50	9
22	2	18	24	1	54	57	1	31	40	1	8	32	45	33	22	43	8
23	2	17	46	1	54	25	1	31	14	1	8	12	45	20	22	36	7
24	2	17	7	1	53	51	1	30	46	1	7	51	45	6	22	29	6
25	2	16	26	1	53	16	1	30	17	1	7	29	44	51	22	21	5
26	2	15	42	1	52	39	1	29	46	1	7	6	44	35	22	13	4
27	2	14	55	1	52	0	1	29	14	1	6	42	44	18	22	5	3
28	2	14	6	1	51	19	1	28	40	1	6	16	44	0	21	56	2
29	2	13	15	1	50	35	1	28	5	1	5	49	43	42	21	47	1
30	2	12	21	1	49	49	1	27	29	1	5	21	43	24	21	37	0
	6°			5°			4°			3°			2°		1°		

+

Longitude { 5. S. with north latitude.
11. S. with south latitude.

Tables for finding the Right Aſcenſion.

Longitude { 0. S. with ſouth latitude.
6. S. with north latitude.

+

	1°		2°		3°			4°			5°			6°			
°	′	″	′	″	°	′	″	°	′	″	°	′	″	°	′	″	°
0	23	54	47	49	1	11	45	1	35	43	1	59	44	2	23	49	30
1	23	53	47	48	1	11	43	1	35	40	1	59	39	2	23	42	29
2	23	52	47	46	1	11	40	1	35	36	1	59	33	2	23	34	28
3	23	51	47	43	1	11	36	1	35	30	1	59	26	2	23	24	27
4	23	50	47	39	1	11	31	1	35	23	1	59	17	2	23	12	26
5	23	49	47	35	1	11	26	1	35	15	1	59	6	2	22	58	25
6	23	47	47	31	1	11	20	1	35	6	1	58	54	2	22	43	24
7	23	45	47	27	1	11	13	1	34	56	1	58	40	2	22	26	23
8	23	43	47	23	1	11	5	1	34	45	1	58	25	2	22	7	22
9	23	40	47	18	1	10	56	1	34	32	1	58	8	2	21	46	21
10	23	37	47	12	1	10	45	1	34	18	1	57	50	2	21	23	20
11	23	34	47	5	1	10	34	1	34	3	1	57	30	2	20	58	19
12	23	30	46	57	1	10	22	1	33	47	1	57	9	2	20	31	18
13	23	26	46	49	1	10	9	1	33	29	1	56	46	2	20	3	17
14	23	22	46	40	1	9	56	1	33	10	1	56	22	2	19	33	16
15	23	18	46	31	1	9	42	1	32	50	1	55	56	2	19	1	15
16	23	13	46	21	1	9	27	1	32	29	1	55	28	2	18	27	14
17	23	8	46	10	1	9	11	1	32	6	1	54	59	2	17	51	13
18	23	2	45	59	1	8	53	1	31	42	1	54	29	2	17	14	12
19	22	56	45	47	1	8	34	1	31	17	1	53	57	2	16	35	11
20	22	50	45	34	1	8	14	1	30	50	1	53	23	2	15	54	10
21	22	43	45	21	1	7	53	1	30	22	1	52	47	2	15	11	9
22	22	36	45	7	1	7	31	1	29	53	1	52	10	2	14	26	8
23	22	29	44	52	1	7	9	1	29	23	1	51	31	2	13	39	7
24	22	22	44	37	1	6	46	1	28	51	1	50	51	2	12	50	6
25	22	14	44	21	1	6	22	1	28	18	1	50	9	2	11	58	5
26	22	6	44	4	1	5	57	1	27	44	1	49	25	2	11	4	4
27	21	57	43	47	1	5	30	1	27	8	1	48	40	2	10	8	3
28	21	48	43	29	1	5	2	1	26	31	1	47	50	2	9	10	2
29	21	39	43	10	1	4	33	1	25	52	1	47	4	2	8	11	1
30	21	29	42	50	1	4	3	1	25	11	1	46	13	2	7	10	0
	1°		2°		3°			4°			5°			6°			

Longitude { 5. S. with ſouth latitude.
11. S. with north latitude.

Tables for finding the Right Ascension.

Longitude { 1. S. with north latitude. / 7. S. with south latitude.

	6°			5°			4°			3°			2°		1°		
°	°	′	″	°	′	″	°	′	″	°	′	″	′	″	′	″	°
0	2	12	21	1	49	49	1	27	29	1	5	21	43	24	21	37	30
1	2	11	25	1	49	1	1	26	50	1	4	52	43	5	21	27	29
2	2	10	27	1	48	11	1	26	10	1	4	22	42	45	21	17	28
3	2	9	26	1	47	20	1	25	29	1	3	51	42	24	21	6	27
4	2	8	22	1	46	27	1	24	46	1	3	18	42	2	20	55	26
5	2	7	16	1	45	32	1	24	2	1	2	44	41	39	20	45	25
6	2	6	8	1	44	35	1	23	16	1	2	9	41	15	20	32	24
7	2	4	57	1	43	35	1	22	28	1	1	33	40	50	20	20	23
8	2	3	43	1	42	33	1	21	38	1	0	55	40	25	20	7	22
9	2	2	26	1	41	29	1	20	46	1	0	16	39	59	19	54	21
10	2	1	7	1	40	23	1	19	53	0	59	36	39	33	19	41	20
11	1	59	45	1	39	15	1	18	58	0	58	55	39	6	19	27	19
12	1	58	20	1	38	4	1	18	1	0	58	12	38	38	19	13	18
13	1	56	53	1	36	51	1	17	2	0	57	28	38	8	18	58	17
14	1	55	23	1	35	36	1	16	2	0	56	43	37	37	18	43	16
15	1	53	50	1	34	18	1	15	0	0	55	56	37	5	18	27	15
16	1	52	14	1	32	58	1	13	56	0	55	8	36	32	18	11	14
17	1	50	35	1	31	36	1	12	56	0	54	18	35	59	17	55	13
18	1	48	54	1	30	11	1	11	42	0	53	27	35	25	17	38	12
19	1	47	10	1	28	44	1	10	32	0	52	35	34	50	17	20	11
20	1	45	23	1	27	15	1	9	21	0	51	41	34	15	17	2	10
21	1	43	33	1	25	43	1	8	8	0	50	46	33	39	16	43	9
22	1	41	40	1	24	9	1	6	53	0	49	50	33	2	16	24	8
23	1	39	44	1	22	32	1	5	36	0	48	52	32	24	16	5	7
24	1	37	45	1	20	53	1	4	17	0	47	53	31	44	15	46	6
25	1	35	43	1	19	12	1	2	56	0	46	53	31	3	15	26	5
26	1	33	38	1	17	29	1	1	33	0	45	51	30	21	15	5	4
27	1	31	30	1	15	43	1	0	8	0	44	48	29	39	14	44	3
28	1	29	20	1	13	55	0	58	42	0	43	43	28	56	14	23	2
29	1	27	7	1	12	4	0	57	14	0	42	37	28	13	14	1	1
30	1	24	51	1	10	11	0	55	44	0	41	30	27	29	13	39	0
		6°			5°			4°			3°			2°		1°	

+

Longitude { 4. S. with north latitude. / 10. S. with south latitude.

Tables for finding the Right Ascension.

Longitude { 1. S. with south latitude. / 7. S. with north latitude.

+

	1°		2°		3°			4°			5°			6°			
°	′	″	′	″	°	′	′	°	′	″	°	′	″	°	′	″	°
0	21	29	42	50	1	4	3	1	25	11	1	46	13	2	7	10	30
1	21	19	42	29	1	3	32	1	24	29	1	45	20	2	6	7	29
2	21	9	42	8	1	3	0	1	23	46	1	44	25	2	5	1	28
3	20	58	41	46	1	2	27	1	23	1	1	43	29	2	3	53	27
4	20	47	41	23	1	1	53	1	22	15	1	42	31	2	2	43	26
5	20	35	41	0	1	1	18	1	21	28	1	41	31	2	1	30	25
6	20	23	40	36	0	0	42	1	20	39	1	40	29	2	0	15	24
7	20	10	40	11	0	0	4	1	19	49	1	39	25	1	58	58	23
8	19	57	39	45	0	59	25	1	18	57	1	38	19	1	57	39	22
9	19	44	39	18	0	58	45	1	18	3	1	37	12	1	56	18	21
10	19	30	38	51	0	58	3	1	17	7	1	36	3	1	54	54	20
11	19	16	38	23	0	57	21	1	16	10	1	34	52	1	53	28	19
12	19	2	37	54	0	56	37	1	15	11	1	33	39	1	51	59	18
13	18	47	37	24	0	55	52	1	14	11	1	32	24	1	50	28	7
14	18	32	36	53	0	55	6	1	13	10	1	31	7	1	48	55	16
15	18	16	36	22	0	54	19	1	12	7	1	29	47	1	47	19	15
16	18	0	35	49	0	53	31	1	11	2	1	28	25	1	45	41	14
17	17	43	35	16	0	52	41	1	9	55	1	27	1	1	44	1	13
18	17	26	34	42	0	51	50	1	8	47	1	25	35	1	42	18	12
19	17	9	34	7	0	50	57	1	7	37	1	24	8	1	40	33	11
20	16	51	33	31	0	50	3	1	6	25	1	22	39	1	38	46	10
21	16	33	32	54	0	49	8	1	5	11	1	21	8	1	36	56	9
22	16	14	32	17	0	48	12	1	3	56	1	19	35	1	35	4	8
23	15	55	31	39	0	47	15	1	2	39	1	17	59	1	33	9	7
24	15	35	31	0	0	46	16	1	1	21	1	16	21	1	31	12	6
25	15	15	30	20	0	45	16	1	0	2	1	14	41	1	29	13	5
26	14	55	29	39	0	44	15	0	58	41	1	12	59	1	27	12	4
27	14	34	28	57	0	43	13	0	57	18	1	11	15	1	25	8	3
28	14	13	28	15	0	42	9	0	55	54	1	9	30	1	23	2	2
29	13	51	27	32	0	41	4	0	54	28	1	7	43	1	20	53	1
30	13	29	26	48	0	39	58	0	53	0	1	5	54	1	18	41	0
	1°		2°		3°			4°			5°			6°			

Longitude { 4. S. with south latitude. / 10. S. with north latitude.

Tables for finding the Right Ascension.

Longitude { 2. S. with north latitude.
8. S. with south latitude.

	6°			5°			4°		3°		2°		1°		
°	°	′	″	°	′	″	′	″	′	″	′	″	′	″	°
0	1	24	51	1	10	11	55	44	41	30	27	29	13	39	30
1	1	22	32	1	8	16	54	12	40	22	26	43	13	16	29
2	1	20	11	1	6	19	52	39	39	12	25	57	12	53	28
3	1	17	47	1	4	19	51	4	38	1	25	10	12	30	27
4	1	15	20	1	2	17	49	27	36	49	24	22	12	6	26
5	1	12	50	1	0	13	47	48	35	35	23	33	11	42	25
6	1	10	18	0	58	7	46	8	34	20	22	43	11	17	24
7	1	7	43	0	55	59	44	26	33	4	21	52	10	52	23
8	1	5	6	0	53	49	42	42	31	47	21	1	10	26	22
9	1	2	26	0	51	37	40	57	30	29	20	9	10	0	21
10	0	59	44	0	49	22	39	10	29	9	19	17	9	34	20
11	0	56	59	0	47	6	37	22	27	48	18	24	9	8	19
12	0	54	12	0	44	48	35	33	26	26	17	30	8	41	18
13	0	51	24	0	42	29	33	42	25	4	16	35	8	14	17
14	0	48	34	0	40	8	31	50	23	41	15	40	7	47	16
15	0	45	42	0	37	45	29	57	22	17	14	44	7	19	15
16	0	42	48	0	35	21	28	3	20	52	13	48	6	51	14
17	0	39	52	0	32	56	26	8	19	26	12	51	6	23	13
18	0	36	55	0	30	29	24	12	17	59	11	54	5	54	12
19	0	33	56	0	28	1	22	14	16	32	10	56	5	25	11
20	0	30	55	0	25	32	20	15	15	4	9	58	4	56	10
21	0	27	53	0	23	2	18	16	13	35	8	59	4	27	9
22	0	24	50	0	20	31	16	16	12	6	8	0	3	58	8
23	0	21	46	0	17	59	14	16	10	36	7	1	3	28	7
24	0	18	41	0	15	26	12	15	9	6	6	1	2	59	6
25	0	15	36	0	12	53	10	13	7	36	5	1	2	29	5
26	0	12	30	0	10	19	8	11	6	5	4	1	1	59	4
27	0	9	23	0	7	45	6	9	4	34	3	1	1	30	3
28	0	6	16	0	5	10	4	6	3	3	2	0	1	0	2
29	0	3	8	0	2	35	2	3	1	32	1	0	0	30	1
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		6°			5°			4°		3°		2°		1°	

+

Longitude { 3. S. with north latitude.
9. S. with south latitude.

Tables for finding the Right Ascension.

Longitude { 2. S. with south latitude. / 8. S. with north latitude.

+

	1°		2°		3°		4°		5°			6°			
°	′	″	′	″	′	″	′	″	°	′	″	°	′	″	°
0	13	29	26	48	39	58	53	0	1	5	54	1	18	41	30
1	13	6	26	3	38	51	51	31	1	4	3	1	16	27	29
2	12	43	25	17	37	43	50	0	1	2	10	1	14	11	28
3	12	20	24	31	36	34	48	28	1	0	15	1	11	54	27
4	11	56	23	44	35	23	46	54	0	58	18	1	9	35	26
5	11	32	22	56	34	11	45	19	0	56	20	1	7	14	25
6	11	8	22	7	32	58	43	43	0	54	20	1	4	51	24
7	10	43	21	18	31	44	42	5	0	52	18	1	2	26	23
8	10	18	20	28	30	29	40	26	0	50	14	0	59	58	22
9	9	52	19	37	29	13	38	45	0	48	9	0	57	28	21
10	9	26	18	45	27	57	37	3	0	46	2	0	54	56	20
11	9	0	17	53	26	40	35	20	0	43	54	0	52	23	19
12	8	33	17	0	25	22	33	36	0	41	44	0	49	48	18
13	8	6	16	7	24	3	31	51	0	39	33	0	47	11	17
14	7	39	15	13	22	42	30	4	0	37	21	0	44	33	16
15	7	12	14	19	21	20	28	16	0	35	7	0	41	54	15
16	6	45	13	24	19	58	26	27	0	32	52	0	39	13	14
17	6	17	12	29	18	35	24	38	0	30	36	0	36	31	13
18	5	49	11	33	17	12	22	48	0	28	19	0	33	47	12
19	5	21	10	37	15	48	20	57	0	26	1	0	31	2	11
20	4	52	9	40	14	24	19	5	0	23	42	0	28	16	10
21	4	23	8	43	12	59	17	12	0	21	22	0	25	29	9
22	3	54	7	46	11	33	15	19	0	19	1	0	22	41	8
23	3	25	6	48	10	7	13	25	0	16	40	0	19	53	7
24	2	56	5	50	8	41	11	31	0	14	18	0	17	4	6
25	2	27	4	52	7	15	9	36	0	11	56	0	14	14	5
26	1	58	3	54	5	48	7	41	0	9	34	0	11	24	4
27	1	29	2	56	4	21	5	46	0	7	11	0	8	34	3
28	1	0	1	58	2	54	3	51	0	4	48	0	5	43	2
29	0	30	0	59	1	27	1	56	0	2	24	0	2	52	1
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1°		2°		3°		4°		5°			6°			

Longitude { 3. S. with south latitude. / 9. S. with north latitude.

Table for correcting the Ecliptic Declination.

Subtract the numbers in this Table from the Latitude.

Ecliptic Declin.	Latitude of the same name with the Declination.					
	1°	2°	3°	4°	5°	6°
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0	4 58	9 56	14 55	19 54	24 54	29 54
1	4 58	9 56	14 54	19 53	24 53	29 52
2	4 57	9 54	14 50	19 48	24 47	29 45
3	4 55	9 49	14 43	19 39	24 36	29 33
4	4 51	9 42	14 33	19 27	24 22	29 16
5	4 46	9 33	14 21	19 11	24 2	28 54
6	4 40	9 22	14 5	18 49	23 37	28 24
7	4 33	9 8	13 46	18 25	23 6	27 49
8	4 25	8 53	13 23	17 55	22 29	27 5
9	4 17	8 36	12 57	17 21	21 47	26 14
10	4 8	8 17	12 28	16 42	20 58	25 16
11	3 58	7 56	11 56	15 59	20 4	24 12
12	3 46	7 32	11 20	15 12	19 5	23 1
13	3 33	7 6	10 41	14 20	18 0	21 43
14	3 19	6 38	9 59	13 22	16 48	20 17
15	3 13	6 7	9 13	12 21	15 32	18 45
16	2 46	5 33	8 23	11 14	14 9	17 4
17	2 28	4 58	7 29	10 3	12 39	15 16
18	2 9	4 19	6 31	8 45	11 2	13 19
19	1 48	3 38	5 29	7 22	9 18	11 13
20	1 26	2 54	4 23	5 54	7 26	8 59
21	1 3	2 7	3 13	4 20	5 27	6 36
22	0 39	1 18	1 58	2 39	3 20	4 3
23	0 13	0 26	0 39	0 53	1 7	1 21
23°28′	0 0	0 0	0 0	0 0	0 0	0 0

The sum of the diminished latitude and ecliptic declination, with the sign of either, is the declination required.

Table for correcting the Ecliptic Declination.

Subtract the numbers in this Table from the Latitude.

Ecliptic Declin.	The Latitude and Declination of different names.					
	1°	2°	3°	4°	5°	6°
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0	4 58	9 56	14 55	19 54	24 54	29 54
1	4 58	9 55	14 53	19 51	24 51	29 50
2	4 57	9 52	14 48	19 44	24 42	29 39
3	4 54	9 47	14 40	19 32	24 27	29 21
4	4 50	9 39	14 28	19 16	24 6	28 55
5	4 45	9 29	14 13	18 56	23 40	28 23
6	4 39	9 18	13 55	18 33	23 10	27 46
7	4 32	9 5	13 34	18 6	22 35	27 3
8	4 24	8 49	13 10	17 34	21 55	26 14
9	4 15	8 31	12 44	16 58	21 10	25 20
10	4 6	8 11	12 15	16 18	20 20	24 20
11	3 55	7 49	11 42	15 33	19 25	23 14
12	3 43	7 25	11 6	14 44	18 24	22 1
13	3 30	6 59	10 26	13 52	17 18	20 41
14	3 16	6 31	9 44	12 55	16 6	19 15
15	3 1	6 0	8 58	11 54	14 49	17 43
16	2 45	5 26	8 8	10 48	13 26	16 4
17	2 27	4 50	7 15	9 37	11 58	14 18
18	2 8	4 12	6 18	8 21	10 24	12 25
19	1 47	3 32	5 17	7 1	8 44	10 25
20	1 25	2 50	4 13	5 36	6 58	8 19
21	1 2	2 5	3 5	4 6	5 6	6 5
22	0 38	1 16	1 54	2 31	3 7	3 43
23	0 13	0 25	0 38	0 50	1 2	1 14
23°28	0 0	0 0	0 0	0 0	0 0	0 0

The difference between the diminiſhed latitude and the ecliptic declination, with the ſign of the greater, is the declination ſought.

Tables of the Mean Motions of the Moon from the Sun.

	A. D.	S.	°	′	″
	1761	9	20	47	17
	1781	2	4	12	47
	1791	10	4	49	47
B	1792	2	26	38	39
	1793	7	6	16	4
	1794	11	15	53	29
	1795	3	25	30	54
B	1796	8	17	19	45
	1797	0	26	57	10
	1798	5	6	34	35
	1799	9	16	12	0
	1800	1	25	49	25
	1801	6	5	26	49
	1802	10	15	4	15
	1803	2	24	41	39
B	1804	7	16	30	31
	1805	11	26	7	56
	1806	4	5	45	20
	1807	8	15	22	45
B	1808	1	7	11	37
	1809	5	16	49	3
	1810	9	26	26	28
	1811	2	6	3	54
B	1812	6	27	52	47
	1813	11	7	30	12
	1814	3	17	7	38
	1815	7	26	45	3
B	1816	0	18	33	56
	1817	4	28	11	22
	1818	9	7	48	47
	1819	1	17	26	13
B	1820	6	9	15	6
	1821	10	18	52	32

Years complete.					
		S.	°	′	″
	1	4	9	37	24
	2	8	19	14	49
	3	0	28	52	14
B	4	5	20	41	6
	5	10	0	18	30
	6	2	9	55	54
	7	6	19	33	19
B	8	11	11	22	10
	9	3	20	59	36
	10	8	0	37	0
	11	0	10	14	24
B	12	5	2	3	16
	13	9	11	40	40
	14	1	21	18	5
	15	6	0	55	30
B	16	10	22	44	21
	17	3	2	21	46
	18	7	11	59	10
	19	11	21	36	35
B	20	4	13	25	26

Months.				
	S.	°	′	″
January	0	0	0	0
February	0	17	54	48
March	11	29	15	16
April	0	17	10	3
May	0	22	53	23
June	1	10	48	11
July	1	16	31	22
Auguſt	2	4	26	20
September	2	22	21	8
October	2	28	4	29
November	3	15	59	16
December	3	21	42	37

In months after February of biſſextile years ſubtract one day from the time found by the Tables.

Tables of the Mean Motions of the Moon from the Sun.

Days.				
	S.	°	′	″
1	0	12	11	27
2	0	24	22	53
3	1	6	34	20
4	1	18	45	47
5	2	0	57	13
6	2	13	8	40
7	2	25	20	7
8	3	7	31	33
9	3	19	43	0
10	4	1	54	27
11	4	14	5	53
12	4	26	17	20
13	5	8	28	47
14	5	20	40	13
15	6	2	15	40
16	6	15	3	7
17	6	27	14	33
18	7	9	26	0
19	7	21	37	27
20	8	3	48	53
21	8	16	0	20
22	8	28	11	47
23	9	10	23	13
24	9	22	34	40
25	10	4	46	7
26	10	16	57	33
27	10	29	9	0
28	11	11	20	27
29	11	23	31	53
30	0	5	43	20
31	0	17	54	47

Hours and Minutes.							
H. ′ ″	° ′ ″ ‴			H. ′ ″	° ′ ″ ‴		
1	0	30	29	31	15	44	48
2	1	0	57	32	16	15	17
3	1	31	26	33	16	45	45
4	2	1	54	34	17	16	13
5	2	32	23	35	17	46	42
6	3	2	52	36	18	17	10
7	3	33	20	37	18	47	39
8	4	3	49	38	19	18	7
9	4	34	18	39	19	48	36
10	5	4	46	40	20	19	5
11	5	35	15	41	20	49	33
12	6	5	43	42	21	20	2
13	6	36	12	43	21	50	31
14	7	6	41	44	22	20	59
15	7	37	9	45	22	51	28
16	8	7	38	46	23	21	56
17	8	38	6	47	23	52	25
18	9	8	35	48	24	22	54
19	9	39	4	49	24	53	22
20	10	9	32	50	25	23	51
21	10	40	1	51	25	54	19
22	11	10	30	52	26	24	48
23	11	40	59	53	26	55	17
24	12	11	28	54	27	25	45
25	12	41	56	55	27	56	14
26	13	12	25	56	28	26	43
27	13	42	54	57	28	57	12
28	14	13	22	58	29	27	40
29	14	43	51	59	29	58	9
30	15	14	19	60	30	28	37

	D.	h.	m.	″
A Lunation	= 29	12	44	3
Half a lunation	= 14	18	22	2

TABLES OF THE PLANETS MOTIONS.

TABLES OF MERCURY's MOTIONS.

The Mean Motions of Mercury in Current Years.

Years.	Longitude.				Apogee.				Node.			
A. D.	S.	°	′	″	S.	°	′	″	S.	°	′	″
1761	4	16	23	5	8	13	44	17	1	15	28	39
1781	5	1	11	57	8	14	3	2	1	15	43	5
1791	11	6	33	37	8	14	12	24	1	15	50	18
B 1792	1	4	22	13	8	14	13	20	1	15	51	1
1793	2	28	5	16	8	14	14	16	1	15	51	44
1794	4	21	48	19	8	14	15	12	1	15	52	27
1795	6	15	31	22	8	14	16	8	1	15	53	10
B 1796	8	13	19	58	8	14	17	6	1	15	53	55
1797	10	7	3	1	8	14	18	2	1	15	54	38
1798	0	0	46	4	8	14	18	58	1	15	55	21
1799	1	24	29	7	8	14	19	55	1	15	56	4
1800	3	18	12	10	8	14	20	51	1	15	56	48
1801	5	11	55	13	8	14	21	47	1	15	57	31
1802	7	5	38	16	8	14	22	43	1	15	58	14
1803	8	29	21	19	8	14	23	39	1	15	58	57
B 1804	10	27	9	55	8	14	24	36	1	15	59	41
1805	0	20	52	58	8	14	25	32	1	16	0	24
1806	2	14	36	1	8	14	26	29	1	16	1	8
1807	4	8	19	4	8	14	27	25	1	16	1	51
B 1808	6	6	7	40	8	14	28	21	1	16	2	34
1809	7	29	50	43	8	14	29	17	1	16	3	17
1810	9	23	33	46	8	14	30	14	1	16	4	1
1811	11	17	16	49	8	14	31	10	1	16	4	44
B 1812	1	15	5	25	8	14	32	6	1	16	5	27
1813	3	8	48	28	8	14	33	2	1	16	6	10
1814	5	2	31	31	8	14	33	58	1	16	6	53
1815	6	26	14	34	8	14	34	54	1	16	7	36
B 1816	8	24	3	10	8	14	35	50	1	16	8	19
1817	10	17	46	13	8	14	36	46	1	16	9	3
1818	0	11	29	16	8	14	37	42	1	16	9	46
1819	2	5	12	19	8	14	38	39	1	16	10	29
B 1820	4	3	0	55	8	14	39	35	1	16	11	12
1821	5	26	43	58	8	14	40	31	1	16	11	55
1841	6	11	32	50	8	14	59	16	1	16	26	21

Mercury's Mean Motion in Julian Years.

	Years.	Longitude. S.	°	′	″	Apogee. °	′	″	Node. °	′	″
	1	1	23	43	3	0	0	56	0	0	43
	2	3	17	26	7	0	1	52	0	1	27
	3	5	11	9	10	0	2	49	0	2	10
B	4	7	8	57	46	0	3	45	0	2	53
	5	9	2	40	50	0	4	41	0	3	36
	6	10	26	23	53	0	5	37	0	4	20
	7	0	20	6	57	0	6	34	0	5	3
B	8	2	17	55	33	0	7	30	0	5	46
	9	4	11	38	36	0	8	26	0	6	30
	10	6	5	21	40	0	9	22	0	7	13
	11	7	29	4	43	0	10	19	0	7	56
B	12	9	26	53	19	0	11	15	0	8	40
	13	11	20	36	23	0	12	11	0	9	23
	14	1	14	19	26	0	13	8	0	10	6
	15	3	8	2	29	0	14	4	0	10	49
B	16	5	5	51	6	0	15	0	0	11	33
	17	6	29	34	9	0	15	56	0	12	16
	18	8	23	17	12	0	16	52	0	12	59
	19	10	17	0	16	0	17	49	0	13	43
B	20	0	14	48	52	0	18	45	0	14	26
B	40	0	29	37	44	0	37	30	0	28	52
B	60	1	14	26	36	0	56	15	0	43	18
B	80	1	29	15	28	1	15	0	0	57	44
B	100	2	14	4	20	1	33	45	1	12	10

Mercury's Mean Motions in Months.

	Longitude.				Apo.	Node
	S.	°	′	″	″	″
January	0	0	0	0	0	0
Feb.	4	6	51	50	5	4
March	8	1	27	1	9	7
April	0	8	18	50	14	11
May	4	11	5	7	18	14
June	8	17	56	56	23	18
July	0	20	43	13	28	22
Auguſt	4	27	35	2	33	25
Sept.	9	4	26	51	37	29
Octob.	1	7	13	8	42	32
Novem.	5	14	4	57	47	36
Decem.	9	16	51	14	51	40

In January and February of biſſextile years take away a day from the time.

Mean Motions of Mercury in Days

Days	Longitude.				Apo.	Node
	S.	°	′	″	″	″
1	0	4	5	33	0	0
2	0	8	11	5	0	0
3	0	12	16	38	1	0
4	0	16	22	10	1	1
5	0	20	27	43	1	1
6	0	24	33	15	1	1
7	0	28	38	48	1	1
8	1	2	44	20	1	1
9	1	6	49	53	2	1
10	1	10	55	26	2	1
11	1	15	0	58	2	1
12	1	19	6	31	2	2
13	1	23	12	3	2	2
14	1	27	17	36	2	2
15	2	1	23	8	2	2
16	2	5	28	41	3	2
17	2	9	34	13	3	2
18	2	13	39	46	3	2
19	2	17	45	19	3	2
20	2	21	50	51	3	2
21	2	25	56	24	3	3
22	3	0	1	56	4	3
23	3	4	7	29	4	3
24	3	8	13	2	4	3
25	3	12	18	34	4	3
26	3	16	24	7	4	3
27	3	20	29	39	4	3
28	3	24	35	12	4	3
29	3	28	40	44	4	3
30	4	2	46	17	5	4
31	4	6	51	50	5	4

Mean Motions of Mercury in Hours, Minutes, and Seconds.

H.	° ′ ″		′	′ ″ ‴
′	′ ″ ‴		″	″ ‴ ⁗
″	″ ‴ ⁗			
1	0 10 14		31	5 17 9
2	0 20 28		32	5 27 23
3	0 30 42		33	5 37 37
4	0 40 55		34	5 47 51
5	0 51 9		35	5 58 5
6	1 1 23		36	6 8 19
7	1 11 37		37	6 18 33
8	1 21 51		38	6 28 46
9	1 32 5		39	6 39 0
10	1 42 19		40	6 49 14
11	1 52 33		41	6 59 28
12	2 2 46		42	7 9 42
13	2 13 0		43	7 19 56
14	2 23 14		44	7 30 10
15	2 33 28		45	7 40 24
16	2 43 42		46	7 50 38
17	2 53 56		47	8 0 52
18	3 4 10		48	8 11 6
19	3 14 24		49	8 21 20
20	3 24 38		50	8 31 34
21	3 34 52		51	8 41 48
22	3 45 6		52	8 52 2
23	3 55 20		53	9 2 16
24	4 5 34		54	9 12 30
25	4 15 48		55	9 22 44
26	4 26 2		56	9 32 58
27	4 36 16		57	9 43 12
28	4 46 30		58	9 53 26
29	4 56 44		59	10 3 40
30	5 6 58		60	10 13 54

Equations of Mercury's Centre.

Argument. Mean Anomaly of Mercury.

S.	— 0	— 1	— 2	S.
°	° ′ ″	° ′ ″	° ′ ″	°
0	0 0 0	9 34 42	17 46 53	30
1	0 19 36	9 52 56	18 0 46	29
2	0 39 11	10 11 4	18 14 27	28
3	0 58 46	10 29 6	18 27 56	27
4	1 18 21	10 47 2	18 41 12	26
5	1 37 55	11 4 52	18 54 14	25
6	1 57 28	11 22 35	19 7 3	24
7	2 17 0	11 40 12	19 19 39	23
8	2 36 31	11 57 42	19 32 1	22
9	2 56 0	12 15 5	19 44 8	21
10	3 15 28	12 32 21	19 56 1	20
11	3 34 44	12 49 30	20 7 40	19
12	3 54 18	13 6 31	20 19 3	18
13	4 13 40	13 23 24	20 30 11	17
14	4 33 0	13 40 9	20 41 3	16
15	4 52 18	13 56 46	20 51 40	15
16	5 11 32	14 13 14	21 2 0	14
17	5 30 44	14 29 34	21 12 4	13
18	5 49 53	14 45 45	21 21 51	12
19	6 8 59	15 1 46	21 31 21	11
20	6 28 2	15 17 38	21 40 33	10
21	6 47 1	15 33 21	21 49 27	9
22	7 5 56	15 48 54	21 58 4	8
23	7 24 47	16 4 17	22 6 22	7
24	7 43 34	16 19 29	22 14 21	6
25	8 2 17	16 34 31	22 22 2	5
26	8 20 56	16 49 22	22 29 23	4
27	8 39 30	17 4 2	22 36 24	3
28	8 57 59	17 18 31	22 43 5	2
29	9 16 23	17 32 48	22 49 26	1
30	9 34 42	17 46 53	22 55 26	0
S.	+ 11	+ 10	+ 9	S.

Equations of Mercury's Centre.

Argument. Mean Anomaly of Mercury.

S.	— 3	— 4	— 5	S.
°	° ′ ″	° ′ ″	° ′ ″	°
0	22 55 26	22 45 28	14 55 11	30
1	23 1 5	22 37 50	14 30 55	29
2	23 6 22	22 29 40	14 6 9	28
3	23 11 18	22 20 58	13 40 53	27
4	23 15 52	22 11 43	13 15 7	26
5	23 20 3	22 1 57	12 48 52	25
6	23 23 51	21 51 37	12 22 9	24
7	23 27 16	21 40 44	11 54 28	23
8	23 30 18	21 29 18	11 27 21	22
9	23 32 55	21 17 19	10 59 17	21
10	23 35 9	21 4 46	10 30 48	20
11	23 36 57	20 51 40	10 1 55	19
12	23 38 21	20 37 59	9 32 59	18
13	23 39 20	20 23 45	9 3 0	17
14	23 39 53	20 8 56	8 32 59	16
15	23 39 59	19 53 33	8 2 38	15
16	23 39 39	19 37 37	7 31 58	14
17	23 38 53	19 21 6	7 1 0	13
18	23 37 39	19 4 0	6 29 44	12
19	23 35 57	18 46 21	5 58 12	11
20	23 33 48	18 28 7	5 26 26	10
21	23 31 11	18 9 20	4 54 26	9
22	23 28 5	17 49 58	4 22 15	8
23	23 24 30	17 30 3	3 49 52	7
24	23 20 26	17 9 34	3 17 20	6
25	23 15 52	16 48 31	2 44 39	5
26	23 10 48	16 26 56	2 11 51	4
27	23 5 14	16 4 48	1 38 58	3
28	22 59 10	15 42 8	1 6 1	2
29	22 52 34	15 18 55	0 33 1	1
30	22 45 28	14 55 11	0 0 0	0
S.	+ 8	+ 7	+ 6	S.

Logarithms of Mercury's Distances from the Sun.

Argument. The Mean Anomaly of Mercury.

S.	0	1	2	S.
0°	4.669131	4.662120	4.640896	30°
1	4.669123	4.661643	4.639940	29
2	4.669100	4.661151	4.638968	28
3	4.669061	4.660643	4.637980	27
4	4.669006	4.660119	4.636976	26
5	4.668936	4.659579	4.635956	25
6	4.668851	4.659024	4.634920	24
7	4.668750	4.658452	4.633868	23
8	4.668633	4.657864	4.632800	22
9	4.668501	4.657261	4.631716	21
10	4.668353	4.656642	4.630617	20
11	4.668190	4.656007	4.629501	19
12	4.668012	4.655356	4.628370	18
13	4.667817	4.654688	4.627223	17
14	4.657607	4.654005	4.626060	16
15	4.667382	4.653306	4.624881	15
16	4.667141	4.652591	4.623687	14
17	4.666884	4.651860	4.622478	13
18	4.666612	4.651113	4.621253	12
19	4.666324	4.650350	4.620012	11
20	4.666020	4.649571	4.618756	10
21	4.665701	4.648775	4.617485	9
22	4.665365	4.647964	4.616199	8
23	4.665014	4.647136	4.614898	7
24	4.664648	4.646293	4.613582	6
25	4.664266	4.645433	4.612251	5
26	4.663868	4.644558	4.610905	4
27	4.663455	4.643667	4.609545	3
28	4.663026	4.642759	4.608170	2
29	4.662581	4.641835	4.606781	1
30	4.662120	4.640896	4.005378	0
	11	10	9	

Logarithms of Mercury's Distance from the Sun.

Argument. The Mean Anomaly of Mercury.

S.	3	4	5	S.
0°	4.605378	4.557951	4.509939	30°
1	4.603961	4.556255	4.508606	29
2	4.602530	4.554557	4.507302	28
3	4.601085	4.552859	4.506030	27
4	4.599627	4.551160	4.504791	26
5	4.598155	4.549462	4.503586	25
6	4.596671	4.547764	4.502416	24
7	4.595174	4.546069	4.501283	23
8	4.593664	4.544377	4.500186	22
9	4.592142	4.542689	4.499129	21
10	4.590608	4.541005	4.498113	20
11	4.589062	4.539328	4.497137	19
12	4.587505	4.537656	4.496204	18
13	4.585937	4.535993	4.495314	17
14	4.584358	4.534338	4.494470	16
15	4.582768	4.532693	4.493671	15
16	4.581168	4.531058	4.492919	14
17	4.579558	4.529435	4.492215	13
18	4.577939	4.527825	4.491557	12
19	4.576311	4.526229	4.490950	11
20	4.574675	4.524648	4.490393	10
21	4.573030	4.523084	4.489887	9
22	4.571378	4.521537	4.489432	8
23	4.569719	4.520009	4.489029	7
24	4.568053	4.518501	4.488679	6
25	4.566381	4.517014	4.488382	5
26	4.564704	4.515548	4.488138	4
27	4.563022	4.514107	4.487948	3
28	4.561335	4.512691	4.487813	2
29	4.559645	4.511301	4.487732	1
30	4.557951	4.509939	4.487704	0
	8	7	6	

The Inclination of Mercury's Orbit, its Reduction to the Ecliptic, and the Logarithm of Curtation.

Argument. Heliocentric Long. — the Long. of the ☊.

	S. + 0 S. — 6 Inclination.			Reduc. —		Log. Curt.	+ 1 — 7 Inclination.			Reduc. —		Log. Curt.	
°	°	′	″	′	″		°	′	″	′	″		°
0	0	0	0	0	0	0	3	29	17	11	5	805	30
1	0	7	18	0	27	1	3	35	35	11	18	855	29
2	0	14	36	0	53	4	3	41	49	11	30	905	28
3	0	21	54	1	20	9	3	47	59	11	42	956	27
4	0	29	11	1	47	16	3	54	5	11	52	1008	26
5	0	36	27	2	13	24	4	0	7	12	2	1060	25
6	0	43	43	2	39	35	4	6	4	12	11	1114	24
7	0	50	59	3	5	48	4	11	58	12	19	1168	23
8	0	58	13	3	31	62	4	17	46	12	26	1222	22
9	1	5	26	3	57	79	4	23	30	12	32	1277	21
10	1	12	38	4	22	97	4	29	9	12	37	1333	20
11	1	19	49	4	47	117	4	34	43	12	41	1388	19
12	1	26	58	5	12	139	4	40	12	12	45	1444	18
13	1	34	6	5	36	163	4	45	36	12	47	1501	17
14	1	41	12	6	0	188	4	50	55	12	48	1557	16
15	1	48	17	6	23	215	4	56	9	12	49	1614	15
16	1	55	19	6	46	244	5	1	17	12	48	1670	14
17	2	2	19	7	9	275	5	6	19	12	47	1726	13
18	2	9	17	7	31	307	5	11	16	12	45	1783	12
19	2	16	13	7	52	341	5	16	8	12	42	1839	11
20	2	23	6	8	13	376	5	20	54	12	38	1895	10
21	2	29	57	8	33	413	5	25	34	12	33	1951	9
22	2	36	45	8	53	452	5	30	7	12	27	2006	8
23	2	43	30	9	12	491	5	34	35	12	20	2060	7
24	2	50	12	9	30	532	5	38	57	12	12	2114	6
25	2	56	51	9	48	575	5	43	13	12	3	2167	5
26	3	3	27	10	5	619	5	47	22	11	54	2220	4
27	3	10	0	10	21	664	5	51	25	11	44	2273	3
28	3	16	29	10	36	710	5	55	22	11	33	2325	2
29	3	22	55	10	51	757	5	59	12	11	20	2375	1
30	3	29	17	11	5	805	6	2	56	11	7	2425	0
	—		11	+			—		10	+			
	+		5				+		4				

The Inclination of Mercury's Orbit, its Reduction to the Ecliptic, and the Logarithm of Curtation.

Argument. Heliocentric Long. — the Long. of the ☊.

	+ 2 S. — 8 S. Inclination.			Reduct. —		Log. Curt.	
°	°	′	″	′	″		°
0	6	2	56	11	7	2425	30
1	6	6	32	10	54	2473	29
2	6	10	2	10	39	2521	28
3	6	13	26	10	24	2567	27
4	6	16	43	10	17	2613	26
5	6	19	52	9	51	2657	25
6	6	22	55	9	33	2700	24
7	6	25	51	9	15	2741	23
8	6	28	40	8	56	2781	22
9	6	31	21	8	36	2820	21
10	6	33	56	8	16	2858	20
11	6	36	23	7	55	2894	19
12	6	38	43	7	33	2928	18
13	6	40	55	7	11	2960	17
14	6	43	1	6	49	2991	16
15	6	44	58	6	26	3021	15
16	6	46	19	6	2	3048	14
17	6	48	32	5	38	3074	13
18	6	50	7	5	14	3098	12
19	6	51	35	4	49	3120	11
20	6	52	56	4	24	3141	10
21	6	54	9	3	58	3159	9
22	6	55	14	3	33	3176	8
23	6	56	11	3	7	3191	7
24	6	57	1	2	40	3203	6
25	6	57	44	2	14	3214	5
26	6	58	18	1	47	3223	4
27	6	58	45	1	21	3230	3
28	6	59	4	0	54	3235	2
29	6	59	16	0	27	3238	1
30	6	59	20	0	0	3239	0
	— 9 + 3			+			

TABLES OF VENUS's MOTIONS.

The Mean Motions of Venus in Current Years.

Years.	Longitude.				Apogee.				Node.			
A. D.	S.	°	′	″	S.	°	′	″	S.	°	′	″
1761	0	3	52	4	10	8	4	37	2	14	31	59
1781	6	7	42	4	10	8	20	49	2	14	42	19
1701	9	8	49	54	10	8	28	55	2	14	47	29
B 1792	4	25	13	32	10	8	29	44	2	14	48	0
1793	0	10	1	1	10	8	30	33	2	14	48	31
1794	7	24	48	31	10	8	31	22	2	14	49	2
1795	3	9	36	1	10	8	32	11	2	14	49	33
B 1796	10	25	59	38	10	8	33	0	2	14	50	4
1797	6	10	47	8	10	8	33	49	2	14	50	35
1798	1	25	34	38	10	8	34	38	2	14	51	6
1799	9	10	22	8	10	8	35	27	2	14	51	37
1800	4	25	9	38	10	8	36	13	2	14	52	8
1801	0	9	57	8	10	8	37	2	2	14	52	39
1802	7	24	44	38	10	8	37	51	2	14	53	10
1803	3	9	32	8	10	8	38	40	2	14	53	41
B 1804	10	25	55	45	10	8	39	29	2	14	54	12
1805	6	10	43	15	10	8	40	18	2	14	54	43
1806	1	25	30	45	10	8	41	7	2	14	55	14
1807	9	10	17	15	10	8	41	56	2	14	55	45
B 1808	4	26	41	55	10	8	42	45	2	14	56	16
1809	0	11	29	23	10	8	43	34	2	14	56	47
1810	7	26	16	53	10	8	44	23	2	14	57	18
1811	3	11	4	23	10	8	45	12	2	14	57	49
B 1812	10	27	28	1	10	8	46	1	2	14	58	20
1813	6	12	15	31	10	8	46	50	2	14	58	51
1814	1	27	3	1	10	8	47	39	2	14	59	22
1815	9	11	50	31	10	8	48	28	2	14	59	53
B 1816	4	26	14	9	10	8	49	17	2	15	0	24
1817	0	13	1	39	10	8	50	6	2	15	0	55
1818	7	27	49	9	10	8	50	55	2	15	1	26
1819	3	12	36	39	10	8	51	44	2	15	1	57
B 1820	10	29	0	17	10	8	52	33	2	15	2	28
1821	6	13	47	47	0	8	53	22	2	15	2	59
1841	0	17	38	23	10	9	9	34	2	15	13	19

The Mean Motions of Venus in Julian Years.

Years.		Longitude.				Apogee.			Node.	
		S.	°	′	″	°	′	″	′	″
	1	7	14	47	30	0	0	49	0	31
	2	2	29	35	0	0	1	37	1	2
	3	10	14	22	30	0	2	26	1	33
B	4	6	0	46	7	0	3	14	2	4
	5	1	15	33	37	0	4	3	2	35
	6	9	0	21	7	0	4	52	3	6
	7	4	15	8	37	0	5	40	3	37
B	8	0	1	32	14	0	6	29	4	8
	9	7	16	19	44	0	7	17	4	39
	10	3	1	7	14	0	8	6	5	10
	11	10	15	54	44	0	8	55	5	41
B	12	6	2	18	22	0	9	43	6	12
	13	1	17	5	51	0	10	32	6	43
	14	9	1	53	21	0	11	20	7	14
	15	4	16	40	51	0	12	9	7	45
B	16	0	3	4	29	0	12	58	8	16
	17	7	17	51	59	0	13	46	8	47
	18	3	2	39	28	0	14	35	9	18
	19	10	17	26	58	0	15	23	9	49
B	20	6	3	50	36	0	16	12	10	20
B	40	0	7	41	12	0	32	24	20	40
B	60	6	11	31	48	0	48	36	31	0
B	80	0	15	22	24	1	4	48	41	20
B	100	6	19	13	0	1	21	0	51	40

The Mean Motions of Venus in Months.

	Longitude.				Apo.	Node
	S.	°	′	″	″	″
January	0	0	0	0	0	0
Feb.	1	19	40	2	4	3
March	3	4	31	41	8	5
April	4	24	11	43	12	8
May	6	12	15	37	16	10
June	8	1	55	39	20	13
July	9	19	59	33	24	15
Auguſt	11	9	39	35	28	18
Sept.	0	29	19	37	32	21
Octob.	2	17	23	31	36	23
Novem.	4	7	3	33	40	26
Decem.	5	25	7	28	44	28

In January and February of biſſextile years take away a day from the time.

Mean Motions of Venus in Days

Days	Longitude.				Apo.	Node
	S.	°	′	″	″	″
1	0	1	36	8	0	0
2	0	3	12	16	0	0
3	0	4	48	23	1	0
4	0	6	24	31	1	0
5	0	8	0	39	1	0
6	0	9	36	47	1	0
7	0	11	12	55	1	1
8	0	12	49	3	1	1
9	0	14	25	11	1	1
10	0	16	1	18	1	1
11	0	17	37	26	2	1
12	0	19	13	34	2	1
13	0	20	49	41	2	1
14	0	22	25	49	2	1
15	0	24	1	57	2	1
16	0	25	48	5	2	1
17	0	27	14	13	2	1
18	0	28	50	21	3	2
19	1	0	26	28	3	2
20	1	2	2	36	3	2
21	1	3	38	44	3	2
22	1	5	14	52	3	2
23	1	6	51	0	3	2
24	1	8	27	7	3	2
25	1	10	3	15	3	2
26	1	11	39	23	3	2
27	1	13	15	31	3	2
28	1	14	51	39	4	2
29	1	16	27	47	4	2
30	1	18	3	54	4	3
31	1	19	40	2	4	3

Mean Motions of Venus in Hours, Minutes, and Seconds.

H.	♀ ′ ″		′	′ ″ ‴	
′ ″	″ ‴ ⁗		″	″ ‴ ⁗	
1	0 4 0		31	2 4 10	
2	0 8 1		32	2 8 10	
3	0 12 1		33	2 12 11	
4	0 16 1		34	2 16 11	
5	0 20 2		35	2 20 12	
6	0 24 2		36	2 24 12	
7	0 28 2		37	2 28 12	
8	0 32 3		38	2 32 13	
9	0 36 3		39	2 36 13	
10	0 40 3		40	2 40 13	
11	0 44 3		41	2 44 14	
12	0 48 4		42	2 48 14	
13	0 52 4		43	2 52 14	
14	0 56 4		44	2 56 15	
15	1 0 5		45	3 0 15	
16	1 4 5		46	3 4 15	
17	1 8 5		47	3 8 16	
18	1 12 5		48	3 12 16	
19	1 16 6		49	3 16 16	
20	1 20 6		50	3 20 17	
21	1 24 7		51	3 24 17	
22	1 28 7		52	3 28 17	
23	1 32 7		53	3 32 18	
24	1 36 7		54	3 36 18	
25	1 40 8		55	3 40 18	
26	1 44 8		56	3 44 19	
27	1 48 9		57	3 48 19	
28	1 52 9		58	3 52 19	
29	1 56 9		59	3 56 20	
30	2 0 10		60	4 0 20	

Equations of the Centre of Venus.

Argument. Mean Anomaly of Venus.

S.	— 0		— 1		— 2		— 3		— 4		— 5		S.
°	′	″	′	″	′	″	′	″	′	″	′	″	°
0	0	0	23	29	40	49	47	19	41	10	23	51	30
1	0	49	24	12	41	13	47	20	40	45	23	7	29
2	1	38	24	54	41	13	47	19	40	19	22	23	28
3	2	27	25	35	42	0	47	17	39	53	21	39	27
4	3	16	26	16	42	23	47	14	39	26	20	55	26
5	4	5	26	57	42	44	47	11	38	58	20	10	25
6	4	54	27	37	43	5	47	7	38	29	19	24	24
7	5	43	28	17	43	25	47	2	38	0	18	38	23
8	6	32	28	56	43	45	46	56	37	30	17	52	22
9	7	20	29	35	44	3	46	49	36	59	17	6	21
10	8	9	30	13	44	21	46	41	36	27	16	19	20
11	8	58	30	51	44	38	46	32	35	55	15	32	19
12	9	46	31	28	44	54	46	22	35	23	14	45	18
13	10	33	32	5	45	0	46	12	34	49	13	57	17
14	11	21	32	41	45	23	46	1	34	15	13	9	16
15	12	9	33	16	45	37	45	49	33	40	12	21	15
16	12	56	33	51	45	50	45	36	33	5	11	33	14
17	13	44	34	25	46	2	45	23	32	29	10	44	13
18	14	31	34	58	46	13	45	8	31	52	9	55	12
19	15	17	35	32	46	23	44	53	31	15	9	6	11
20	16	3	36	4	46	32	44	36	30	37	8	17	10
21	16	49	36	35	46	41	44	19	29	59	7	28	9
22	17	35	37	6	46	49	44	2	29	20	6	39	8
23	18	21	37	36	46	56	43	43	28	41	5	49	7
24	19	6	38	6	47	2	43	23	28	1	4	59	6
25	19	51	38	35	47	7	43	3	27	21	4	10	5
26	20	35	39	3	47	11	42	42	26	40	3	20	4
27	21	19	39	31	47	14	42	20	25	59	2	30	3
28	22	3	39	57	47	17	41	58	25	17	1	40	2
29	22	46	40	23	47	19	41	34	24	34	0	50	1
30	23	29	40	49	47	19	41	10	23	51	0	0	0
S.	+	11	+	10	+	9	+	8	+	7	+	6	S.

Logarithms of Venus's Distances from the Sun.

Argument. The Mean Anomaly of Venus.

S.	0	1	2	
0°	4.862359	4.861961	4.860867	30°
1	4.862358	4.861934	4.860821	29
2	4.862356	4.861907	4.860775	28
3	4.862354	4.861879	4.860729	27
4	4.862352	4.861850	4.860682	26
5	4.862348	4.861821	4.860635	25
6	4.862343	4.861791	4.860587	24
7	4.862337	4.861760	4.860539	23
8	4.862330	4.861728	4.860490	22
9	4.862322	4.861696	4.860441	21
10	4.862314	4.861663	4.860392	20
11	4.862304	4.861629	4.860342	19
12	4.862294	4.861594	4.860292	18
13	4.862282	4.861559	4.860242	17
14	4.862270	4.861523	4.860192	16
15	4.862257	4.861486	4.860141	15
16	4.862244	4.861449	4.860090	14
17	4.862229	4.861411	4.860039	13
18	4.862214	4.861373	4.859988	12
19	4.862197	4.861334	4.859936	11
20	4.862180	4.861294	4.859884	10
21	4.862162	4.861254	4.859832	9
22	4.862143	4.861213	4.859780	8
23	4.862123	4.861172	4.859728	7
24	4.862102	4.861130	4.859676	6
25	4.862080	4.861087	4.859623	5
26	4.862058	4.861044	4.859570	4
27	4.862035	4.861000	4.859518	3
28	4.862011	4.860956	4.859465	2
29	4.861986	4.860912	4.859412	1
30	4.861961	4.860867	4.859359	0
S.	11	10	9	

Logarithms of Venus's Distances from the Sun.

Argument. The Mean Anomaly of Venus.

S.	3	4	5	
0°	4.859359	4.857835	4.856709	30°
1	4.859306	4.857789	4.856683	29
2	4.859253	4.857743	4.856657	28
3	4.859200	4.857698	4.856632	27
4	4.859147	4.857653	4.856608	26
5	4.859094	4.857609	4.856585	25
6	4.859041	4.857566	4.856563	24
7	4.858989	4.857523	4.856541	23
8	4.858936	4.857480	4.856520	22
9	4.858884	4.857438	4.656501	21
10	4.858831	4.857397	4.856482	20
11	4.858779	4.857356	4.856464	19
12	4.858727	4.857316	4.856447	18
13	4.858675	4.857276	4.856431	17
14	4.858623	4.857237	4.856415	16
15	4.858572	4.857199	4.856401	15
16	4.858521	4.857161	4.856387	14
17	4.858470	4.857124	4.856373	13
18	4.858419	4.857088	4.856363	12
19	4.858368	4.857053	4.856352	11
20	4.858318	4.857018	4.856342	10
21	4.858268	4.856984	4.856333	9
22	4.858218	4.856950	4.856325	8
23	4.858169	4.856917	4.856318	7
24	4.858120	4.856885	4.856312	6
25	4.858072	4.856854	4.856307	5
26	4.858024	4.856823	4.856303	4
27	4.857976	4.856794	4.856299	3
28	4.857928	4.856765	4.856297	2
29	4.857881	4.856737	4.856295	1
30	4.857835	4.856709	4.856295	0
S.	8	7	6	

The Inclination of the Orbit of Venus, its Reduction to the Ecliptic, and the Logarithm of Curtation.

Argument. Heliocentric Long. — the Long. of the ☊.

	S. + 0 S. — 6 Inclination.			Reduc. —		Log. Curt.	+ 1 — 7 Inclination.			Reduc. —		Log. Curt.	
°	°	′	″	′	″		°	′	″	′	″		°
0	0	0	0	0	0	0	1	41	37	2	36	190	30
1	0	3	33	0	6	0	1	44	41	2	39	201	29
2	0	7	6	0	13	1	1	47	42	2	42	213	28
3	0	10	38	0	19	2	1	50	42	2	44	225	27
4	0	14	11	0	25	4	1	53	39	2	47	237	26
5	0	17	42	0	31	6	1	56	35	2	49	250	25
6	0	21	14	0	37	8	1	59	28	2	51	262	24
7	0	24	46	0	43	11	2	2	19	2	53	275	23
8	0	28	17	0	50	15	2	5	8	2	54	288	22
9	0	31	48	0	56	19	2	7	55	2	56	301	21
10	0	35	17	1	1	23	2	10	39	2	57	314	20
11	0	38	46	1	7	28	2	13	21	2	58	327	19
12	0	42	15	1	13	33	2	16	1	2	59	340	18
13	0	45	43	1	19	39	2	18	38	2	59	353	17
14	0	49	10	1	24	44	2	21	12	3	0	366	16
15	0	52	36	1	30	51	2	23	44	3	0	380	15
16	0	56	1	1	35	58	2	26	13	3	0	393	14
17	0	59	25	1	41	65	2	28	40	2	59	406	13
18	1	2	48	1	46	72	2	31	4	2	59	420	12
19	1	6	10	1	51	80	2	33	25	2	58	433	11
20	1	9	30	1	56	89	2	35	43	2	57	446	10
21	1	12	50	2	0	97	2	37	59	2	56	459	9
22	1	16	8	2	5	106	2	40	12	2	54	472	8
23	1	19	24	2	9	116	2	42	21	2	53	485	7
24	1	22	40	2	14	125	2	44	28	2	51	497	6
25	1	25	54	2	18	135	2	46	32	2	49	510	5
26	1	29	5	2	22	146	2	48	32	2	47	522	4
27	1	32	16	2	26	156	2	50	30	2	44	534	3
28	1	35	25	2	29	167	2	52	24	2	42	546	2
29	1	38	32	2	32	178	2	54	15	2	39	558	1
30	1	41	37	2	36	190	2	56	4	2	36	570	0
	S. —		11	+			—		10	+			
	S. +		5				+		4				

The Inclination of the Orbit of Venus, its Reduction to the Ecliptic, and the Logarithm of Curtation.

Argument. Heliocentric Long. — the Long. of the ☊.

	+ 2 S. — 8 S. Inclination.	Reduct. —	Log. Curt.	
°	° ′ ″	′ ″		°
0	2 56 4	2 36	570	30
1	2 57 49	2 32	581	29
2	2 59 30	2 29	592	28
3	3 1 9	2 26	603	27
4	3 2 44	2 22	614	26
5	3 4 16	2 18	624	25
6	3 5 44	2 14	634	24
7	3 7 9	2 9	644	23
8	3 8 30	2 5	653	22
9	3 9 49	2 0	662	21
10	3 11 3	1 56	671	20
11	3 12 14	1 51	679	19
12	3 13 22	1 46	687	18
13	3 14 26	1 [illegible]	695	17
14	3 15 27	1 35	702	16
15	3 16 24	1 30	709	15
16	3 17 17	1 24	716	14
17	3 18 6	1 19	721	13
18	3 18 53	1 13	727	12
19	3 19 35	1 7	732	11
20	3 20 14	1 1	737	10
21	3 20 50	0 56	741	9
22	3 21 21	0 50	745	8
23	3 21 49	0 43	749	7
24	3 22 13	0 37	752	6
25	3 22 33	0 31	754	5
26	3 22 50	0 25	756	4
27	3 23 3	0 19	758	3
28	3 23 12	0 13	759	2
29	3 23 18	0 6	760	1
30	3 23 20	0 0	760	0
	— 9 S. + 3 S.	+		

TABLES OF THE MOTIONS OF MARS.

The Mean Motions of Mars in Current Years.

Years.	Longitude.				Apogee.				Node.			
A. D.	S.	°	′	″	S.	°	′	″	S.	°	′	″
1761	10	27	42	5	5	1	40	41	1	17	43	46
1781	6	16	2	31	5	2	3	1	1	17	53	6
1791	10	9	57	1	5	2	14	11	1	17	57	46
B 1792	4	21	45	37	5	2	15	18	1	17	58	14
1793	11	3	2	47	5	2	16	25	1	17	58	42
1794	5	14	19	56	5	2	17	32	1	17	59	10
1795	11	25	37	6	5	2	18	39	1	17	59	38
B 1796	6	7	25	42	5	2	19	46	1	18	0	6
1797	0	18	42	52	5	2	20	53	1	18	0	34
1798	7	0	0	1	5	2	22	0	1	18	1	2
1799	1	11	17	11	5	2	23	7	1	18	1	30
1800	7	22	34	21	5	2	24	14	1	18	1	58
1801	2	3	51	30	5	2	25	21	1	18	2	26
1802	8	15	8	40	5	2	26	28	1	18	2	54
1803	2	26	25	50	5	2	27	35	1	18	3	22
B 1804	9	8	14	26	5	2	28	42	1	18	3	50
1805	3	19	31	37	5	2	29	49	1	18	4	18
1806	10	0	48	45	5	2	30	56	1	18	4	46
1807	4	12	5	55	5	2	32	3	1	18	5	14
B 1808	10	23	54	31	5	2	33	10	1	18	5	42
1809	5	5	11	41	5	2	34	17	1	18	6	10
1810	11	16	28	38	5	2	35	24	1	18	6	38
1811	5	27	45	48	5	2	36	31	1	18	7	6
B 1812	0	9	34	25	5	2	37	38	1	18	7	34
1813	6	20	51	35	5	2	38	45	1	18	8	2
1814	1	2	8	45	5	2	39	52	1	18	8	30
1815	7	13	25	55	5	2	40	59	1	18	8	58
B 1816	1	25	14	32	5	2	42	6	1	18	9	26
1817	8	6	31	42	5	2	43	13	1	18	9	54
1818	2	17	48	52	5	2	44	20	1	18	10	22
1819	8	29	6	2	5	2	45	27	1	18	10	50
B 1820	3	10	54	39	5	2	46	34	1	18	11	18
1821	9	22	11	49	5	2	47	41	1	18	11	46
1841	5	10	32	15	5	3	10	1	1	18	21	6

The Mean Motions of Mars in Julian Years.

Years.		Longitude.				Apogee.			Node.	
		S.	°	′	″	°	′	″	′	″
	1	6	11	17	10	0	1	7	0	28
	2	0	22	34	19	0	2	14	0	56
	3	7	3	51	29	0	3	21	1	24
B	4	1	15	40	5	0	4	28	1	52
	5	7	26	57	15	0	5	35	2	20
	6	2	8	14	24	0	6	42	2	48
	7	8	19	31	34	0	7	49	3	16
B	8	3	1	20	10	0	8	56	3	44
	9	9	12	37	20	0	10	3	4	12
	10	3	23	54	30	0	11	10	4	40
	11	10	5	11	39	0	12	17	5	8
B	12	4	17	0	16	0	13	24	5	36
	13	10	28	17	25	0	14	31	6	4
	14	5	9	34	35	0	15	38	6	32
	15	11	20	51	44	0	16	45	7	0
B	16	6	2	40	21	0	17	52	7	28
	17	0	13	57	30	0	18	59	7	56
	18	6	25	14	40	0	20	6	8	24
	19	1	6	31	50	0	21	13	8	52
B	20	7	18	20	26	0	22	20	9	20
B	40	3	6	40	52	0	44	40	18	40
B	60	10	25	1	18	1	7	0	28	0
B	80	6	13	21	44	1	29	20	37	20
B	100	2	1	42	10	1	51	40	46	40

The Mean Motions of Mars in Months.

	Longitude.			Apo.	Node
	S.	°	′	″	″	″
January	0	0	0	0	0	0
Feb.	0	16	14	46	6	2
March	1	0	55	13	11	4
April	1	17	9	59	17	7
May	2	2	53	19	22	9
June	2	19	8	5	28	12
July	3	4	51	25	33	14
Auguſt	3	21	6	11	39	16
Sept.	4	7	20	58	45	19
Octob.	4	23	4	17	50	21
Novem.	5	9	19	4	56	23
Decem.	5	25	2	23	61	26

In January and February of biſſextile years take away a day from the time; that is, for the 20th January or February take out the motion for the 19th.

Mean Motions of Mars in Days

Days	Longitude.			Apo.	Node
	°	′	″	″	″
1	0	31	27	0	0
2	1	2	54	0	0
3	1	34	20	1	0
4	2	5	47	1	0
5	2	37	13	1	1
6	3	8	40	1	1
7	3	40	7	1	1
8	4	11	33	1	1
9	4	43	0	2	1
10	5	14	27	2	1
11	5	45	53	2	1
12	6	17	20	2	1
13	6	48	47	2	1
14	7	20	13	3	1
15	7	51	40	3	1
16	8	23	6	3	1
17	8	54	33	3	1
18	9	26	0	3	1
19	9	57	26	3	2
20	10	28	53	4	2
21	11	0	20	4	2
22	11	31	46	4	2
23	12	3	13	4	2
24	12	34	40	4	2
25	13	6	6	5	2
26	13	37	23	5	2
27	14	9	0	5	2
28	14	40	26	5	2
29	15	11	53	5	2
30	15	43	20	5	2
31	16	14	46	6	2

Mean Motions of Mars in Hours, Minutes, and Seconds.

H.	°	′	″	′	″	′	″	‴
1	0	1	19	31	0	40	37	
2	0	2	37	32	0	41	56	
3	0	3	56	33	0	43	14	
4	0	5	14	34	0	44	33	
5	0	6	33	35	0	45	51	
6	0	7	52	36	0	47	10	
7	0	9	10	37	0	48	29	
8	0	10	29	38	0	49	47	
9	0	11	48	39	0	51	6	
10	0	13	6	40	0	52	24	
11	0	14	25	41	0	53	43	
12	0	15	43	42	0	55	2	
13	0	17	2	43	0	56	20	
14	0	18	21	44	0	57	39	
15	0	19	29	45	0	58	58	
16	0	20	58	46	1	0	16	
17	0	22	16	47	1	1	35	
18	0	23	35	48	1	2	53	
19	0	24	54	49	1	4	12	
20	0	26	12	50	1	5	31	
21	0	27	31	51	1	6	49	
22	0	28	49	52	1	8	8	
23	0	30	8	53	1	9	26	
24	0	31	27	54	1	10	45	
25	0	32	45	55	1	12	4	
26	0	34	4	56	1	13	22	
27	0	35	22	57	1	14	41	
28	0	36	41	58	1	15	59	
29	0	38	0	59	1	17	18	
30	0	39	18	60	1	18	37	

Equations of the Centre of Mars.

Argument. Mean Anomaly of Mars.

S.	— 0	— 1	— 2	S.
°	° ′ ″	° ′ ″	° ′ ″	°
0	0 0 0	4 50 16	8 41 45	30
1	0 10 0	4 59 15	8 47 46	29
2	0 20 0	5 8 11	8 53 39	28
3	0 30 0	5 17 2	8 59 23	27
4	0 39 59	5 25 49	9 5 0	26
5	0 49 58	5 34 31	9 10 28	25
6	0 59 56	5 43 9	9 15 48	24
7	1 9 53	5 51 42	9 21 0	23
8	1 19 50	6 0 11	9 26 2	22
9	1 29 45	6 8 34	9 30 56	21
10	1 39 40	6 16 52	9 35 41	20
11	1 49 33	6 25 5	9 40 17	19
12	1 59 24	6 33 13	9 44 43	18
13	2 9 14	6 41 15	9 49 0	17
14	2 19 2	6 49 12	9 53 8	16
15	2 28 49	6 57 3	9 57 6	15
16	2 38 33	7 4 48	10 0 55	14
17	2 48 15	7 12 26	10 4 34	13
18	2 57 55	7 19 59	10 8 3	12
19	3 7 33	7 27 25	10 11 22	11
20	3 17 8	7 34 45	10 14 31	10
21	3 26 41	7 41 59	10 17 30	9
22	3 36 11	7 49 6	10 20 18	8
23	3 45 38	7 56 7	10 22 56	7
24	3 55 2	8 2 59	10 25 24	6
25	4 4 23	8 9 45	10 27 41	5
26	4 13 41	8 16 24	10 49 47	4
27	4 22 55	8 22 55	10 31 42	3
28	4 32 6	8 29 19	10 33 26	2
29	4 41 13	8 35 36	10 35 0	1
30	4 50 16	8 41 45	10 36 22	0
S.	+ 11	+ 10	+ 9	S.

Equations of the Centre of Mars.

Argument. Mean Anomaly of Mars.

S.	— 3	— 4	— 5	S.
°	° ′ ″	° ′ ″	° ′ ″	°
0	10 36 22	9 45 34	5 55 3	30
1	10 37 33	9 40 41	5 44 41	29
2	10 38 33	9 35 37	5 34 10	28
3	10 39 21	9 30 23	5 23 31	27
4	10 39 58	9 24 51	5 12 44	26
5	10 40 23	9 19 9	5 1 49	25
6	10 40 37	9 13 16	4 50 46	24
7	10 40 39	9 7 10	4 39 36	23
8	10 40 29	9 10 52	4 28 19	22
9	10 40 7	8 54 22	4 16 55	21
10	10 39 34	8 47 41	4 5 25	20
11	10 38 49	8 40 47	3 53 48	19
12	10 37 51	8 33 42	3 42 6	18
13	10 36 42	8 26 25	3 30 17	17
14	10 35 20	8 18 57	3 18 23	16
15	10 33 46	8 11 17	3 6 24	15
16	10 32 0	8 3 26	2 54 21	14
17	10 30 1	7 55 24	2 42 13	13
18	10 27 50	7 47 10	2 30 1	12
19	10 25 27	7 38 46	2 17 44	11
20	10 22 52	7 30 11	2 5 24	10
21	10 20 4	7 21 25	1 53 1	9
22	10 17 4	7 12 29	1 40 35	8
23	10 13 51	7 3 22	1 28 6	7
24	10 10 26	6 54 5	1 15 35	6
25	10 6 48	6 44 39	1 3 2	5
26	10 2 58	6 35 3	0 50 28	4
27	9 58 56	6 25 17	0 37 52	3
28	9 54 41	6 15 21	0 25 15	2
29	9 50 14	6 5 17	0 12 38	1
30	9 45 34	5 55 3	0 0 0	0
S.	+ 8	+ 7	+ 6	S.

Logarithms of Mars's Distances from the Sun.

Argument. The Mean Anomaly of Mars.

S.	0	1	2	
0°	5.221516	5.217310	5.205134	30°
1	5.221511	5.217027	5.204606	29
2	5.221497	5.216735	5.204070	28
3	5.221473	5.216435	5.203527	27
4	5.221441	5.216126	5.202977	26
5	5.221398	5.215808	5.202421	25
6	5.221346	5.215481	5.201857	24
7	5.221285	5.215145	5.201287	23
8	5.221215	5.214801	5.200711	22
9	5.221135	5.214448	5.200128	21
10	5.221046	5.214087	5.199538	20
11	5.220947	5.213717	5.198942	19
12	5.220839	5.213338	5.198340	18
13	5.220721	5.212951	5.197732	17
14	5.220594	5.212556	5.197118	16
15	5.220458	5.212152	5.196499	15
16	5.220313	5.211740	5.195874	14
17	5.220158	5.211319	5.195244	13
18	5.219994	5.210890	5.194608	12
19	5.219821	5.210453	5.193967	11
20	5.219639	5.210009	5.193322	10
21	5.219447	5.209556	5.192671	9
22	5.219245	5.209095	5.192015	8
23	5.219035	5.208627	5.191355	7
24	5.218817	5.208152	5.190690	6
25	5.218588	5.207668	5.190021	5
26	5.218351	5.207175	5.189347	4
27	5.218104	5.206674	5.188670	3
28	5.217848	5.206167	5.187989	2
29	5.217583	5.205654	5.187304	1
30	5.217310	5.205134	5.186615	0
S.	11	10	9	

Logarithms of Mars's Distances from the Sun.

Argument. The Mean Anomaly of Mars.

S.	3	4	5	
0°	5.186615	5.165366	5.147586	30°
1	5.185924	5.164676	5.147142	29
2	5.185229	5.163990	5.146710	28
3	5.184531	5.163309	5.146291	27
4	5.183831	5.162632	5.145885	26
5	5.183128	5.161960	5.145492	25
6	5.182423	5.161293	5.145113	24
7	5.181716	5.160631	5.144747	23
8	5.181006	5.159975	5.144395	22
9	5.180295	5.159325	5.144057	21
10	5.179582	5.158682	5.143734	20
11	5.178868	5.158045	5.143425	19
12	5.178153	5.157415	5.143131	18
13	5.177437	5.156792	5.142852	17
14	5.176721	5.156177	5.142587	16
15	5.176004	5.155570	5.142338	15
16	5.175287	5.154971	5.142104	14
17	5.174570	5.154380	5.141886	13
18	5.173853	5.153797	5.141683	12
19	5.173137	5.153223	5.141496	11
20	5.172421	5.152659	5.141325	10
21	5.171706	5.152104	5.141170	9
22	5.170992	5.151559	5.141031	8
23	5.170281	5.151024	5.140908	7
24	5.169572	5.150500	5.140801	6
25	5.168865	5.149986	5.140711	5
26	5.168160	5.149483	5.140637	4
27	5.167457	5.148991	5.140579	3
28	5.166756	5.148511	5.140538	2
29	5.166058	5.148043	5.140513	1
30	5.165366	5.147586	5.140505	0
S.	8	7	6	

The Inclination of the Orbit of Mars, its Reduction to the Ecliptic, and the Logarithm of Curtation.

Argument. Heliocentric Long. — the Long. of the ☊.

	S. + 0 S. — 6 Inclination.			Reduc. —	Log. Curt.	+ 1 — 7 Inclination.			Reduc. —	Log. Curt.	
°	°	′	″	″		°	′	″	″		°
0	0	0	0	0	0	0	55	29	47	56	30
1	0	1	56	2	0	0	57	10	48	60	29
2	0	3	53	4	0	0	58	49	49	64	28
3	0	5	48	6	1	1	0	27	49	67	27
4	0	7	44	7	1	1	2	4	50	71	26
5	0	9	40	9	2	1	3	40	51	74	25
6	0	11	36	11	2	1	5	14	51	78	24
7	0	13	32	13	3	1	6	48	52	82	23
8	0	15	27	15	4	1	8	20	52	86	22
9	0	17	22	17	5	1	9	51	53	90	21
10	0	19	16	18	7	1	11	20	53	93	20
11	0	21	10	20	8	1	12	49	53	97	19
12	0	23	4	22	10	1	14	16	54	101	18
13	0	24	58	24	11	1	15	42	54	105	17
14	0	26	51	25	13	1	17	6	54	109	16
15	0	28	43	27	15	1	18	29	54	113	15
16	0	30	35	29	17	1	19	50	54	117	14
17	0	32	27	30	19	1	21	10	54	121	13
18	0	34	18	32	22	1	22	29	54	125	12
19	0	36	8	33	24	1	23	46	53	129	11
20	0	37	57	35	27	1	25	1	53	133	10
21	0	39	46	36	29	1	26	15	53	137	9
22	0	41	34	37	32	1	27	28	52	141	8
23	0	43	22	39	34	1	28	38	52	144	7
24	0	45	8	40	37	1	29	48	51	148	6
25	0	46	54	41	40	1	30	55	51	152	5
26	0	48	39	43	43	1	32	1	50	155	4
27	0	50	23	44	47	1	33	5	49	159	3
28	0	52	6	45	50	1	34	7	49	163	2
29	0	53	48	46	53	1	35	8	48	166	1
30	0	55	29	47	56	1	36	8	47	170	0
	S. —		11	+		—		10	+		
	S. +		5			+		4			

The Inclination of the Orbit of Mars, its Reduction to the Ecliptic, and the Logarithm of Curtation.

Argument. Heliocentric Long. — the Long. of the ☊.

	+ 2 S. — 8 S. Inclination.	Reduct. —	Log. Curt.	
°	° ′ ″	″		°
0	1 36 8	47	170	30
1	1 37 5	46	173	29
2	1 38 0	45	176	28
3	1 38 54	44	180	27
4	1 39 46	43	183	26
5	1 40 36	41	186	25
6	1 41 24	40	189	24
7	1 42 10	39	192	23
8	1 42 55	37	195	22
9	1 43 38	36	197	21
10	1 44 18	35	200	20
11	1 44 57	33	202	19
12	1 45 34	32	205	18
13	1 46 9	30	207	17
14	1 46 42	29	209	16
15	1 47 13	27	211	15
16	1 47 42	25	213	14
17	1 48 9	24	215	13
18	1 48 35	22	217	12
19	1 48 58	20	218	11
20	1 49 19	18	220	10
21	1 49 38	17	221	9
22	1 49 55	15	222	8
23	1 50 10	13	223	7
24	1 50 23	11	224	6
25	1 50 35	9	225	5
26	1 50 44	7	225	4
27	1 50 51	6	226	3
28	1 50 56	4	226	2
29	1 50 59	2	226	1
30	1 51 0	0	226	0
	— 9 S. + 3 S.	+		

TABLES OF JUPITER's MOTIONS.

The Mean Motions of Jupiter in Current Years.

Years.	Longitude.				Apogee.				Node.			
A. D.	S.	°	′	″	S.	°	′	″	S.	°	′	″
1761	11	8	5	51	6	10	33	53	3	8	17	0
1781	7	15	23	29	6	10	54	33	3	8	37	0
1791	5	18	59	48	6	11	4	53	3	8	47	0
B 1792	6	19	25	19	6	11	5	55	3	8	48	0
1793	7	19	45	47	6	11	6	57	3	8	49	0
1794	8	20	6	19	6	11	7	59	3	8	50	0
1795	9	20	26	49	6	11	9	1	3	8	51	0
B 1796	10	20	52	18	6	11	10	3	3	8	52	0
1797	11	21	12	48	6	11	11	5	3	8	53	0
1798	0	21	33	18	6	11	12	7	3	8	54	0
1799	1	21	53	56	6	11	13	9	3	8	55	0
1800	2	22	14	33	6	11	14	11	3	8	56	0
1801	3	22	35	11	6	11	15	13	3	8	57	0
1802	4	22	55	49	6	11	16	15	3	8	58	0
1803	5	23	16	26	6	11	17	17	3	8	59	0
B 1804	6	23	42	3	6	11	18	19	3	9	0	0
1805	7	24	2	41	6	11	19	21	3	9	1	0
1806	8	24	23	19	6	11	20	23	3	9	2	0
1807	9	24	43	56	6	11	21	25	3	9	3	0
B 1808	10	24	9	33	6	11	22	27	3	9	4	0
1809	11	25	30	11	6	11	23	29	3	9	5	0
1810	0	25	50	49	6	11	24	31	3	9	6	0
1811	1	26	11	26	6	11	25	33	3	9	7	0
B 1812	2	26	37	3	6	11	26	35	3	9	8	0
1813	3	26	57	41	6	11	27	37	3	9	9	0
1814	4	27	18	19	6	11	28	39	3	9	10	0
1815	5	27	38	56	6	11	29	41	3	9	11	0
B 1816	6	28	4	33	6	11	30	43	3	9	12	0
1817	7	28	25	11	6	11	31	45	3	9	13	0
1818	8	28	45	49	6	11	32	47	3	9	14	0
1819	9	29	6	26	6	11	33	49	3	9	15	0
B 1820	10	29	33	3	6	11	34	51	3	9	16	0
1821	11	29	53	41	6	11	35	53	3	9	17	0
1841	8	7	10	47	6	11	56	33	3	9	37	0

The Mean Motions of Jupiter in Julian Years.

	Years.	Longitude. S.	°	′	″	Apogee. °	′	″	Node. ′	″
	1	1	0	20	32	0	0	57	0	36
	2	2	0	41	3	0	1	53	1	11
	3	3	1	1	35	0	2	50	1	47
B	4	4	1	27	6	0	3	47	2	23
	5	5	1	47	38	0	4	44	2	58
	6	6	2	8	10	0	5	40	3	34
	7	7	2	8	41	0	6	37	4	10
B	8	8	2	54	12	0	7	34	4	46
	9	9	3	14	44	0	8	31	5	21
	10	10	3	35	16	0	9	27	5	57
	11	11	3	55	48	0	10	24	6	33
B	12	0	4	21	18	0	11	21	7	8
	13	1	4	41	50	0	12	18	7	44
	14	2	5	2	22	0	13	14	8	20
	15	3	5	22	54	0	14	11	8	56
B	16	4	5	48	24	0	15	8	9	31
	17	5	6	8	26	0	16	4	10	7
	18	6	6	29	28	0	17	1	10	43
	19	7	6	50	0	0	17	58	11	18
B	20	8	7	15	31	0	18	55	11	54
B	40	4	14	31	1	0	37	49	23	48
B	60	0	21	46	32	0	56	44	35	42
B	80	8	29	2	2	1	15	38	47	36
B	100	5	6	17	33	1	34	33	59	30

Mean Motions of Jupiter in Months.

	Longitude.			Apo.	Node
	°	′	″	″	″
January	0	0	0	0	0
Feb.	2	34	37	5	3
March	4	54	17	9	6
April	7	28	54	14	9
May	9	58	32	19	12
June	12	33	9	23	15
July	15	2	47	28	18
Auguſt	17	37	24	33	21
Sept.	20	12	1	38	24
Octob.	22	41	39	42	27
Novem.	25	16	17	47	30
Decem.	27	45	54	52	33

In January and February of biſſextile years take away a day from the time.

Jupiter's Mean Motions in Days.

Days	Longitude.			Apo.	Node
	°	′	″	″	″
1	0	4	59	0	0
2	0	9	58	0	0
3	0	14	58	0	0
4	0	19	57	1	0
5	0	24	56	1	0
6	0	29	56	1	1
7	0	34	55	1	1
8	0	39	54	1	1
9	0	44	53	1	1
10	0	49	53	2	1
11	0	54	52	2	1
12	0	59	52	2	1
13	1	4	50	2	1
14	1	9	50	2	1
15	1	14	49	2	1
16	1	19	48	3	2
17	1	24	47	3	2
18	1	29	47	3	2
19	1	34	46	3	2
20	1	39	45	3	2
21	1	44	45	3	2
22	1	49	44	3	2
23	1	54	43	4	2
24	1	59	42	4	2
25	2	4	42	4	2
26	2	9	41	4	3
27	2	14	40	4	3
28	2	19	39	4	3
29	2	24	39	5	3
30	2	29	38	5	3
31	2	34	37	5	3

Jupiter's Mean Motion in Hours, Minutes, and Seconds.

H.	′	″	′	″	‴
1	0	12	31	6	25
2	0	25	32	6	37
3	0	37	33	6	49
4	0	50	34	7	1
5	1	2	35	7	13
6	1	15	36	7	25
7	1	27	37	7	37
8	1	40	38	7	49
9	1	52	39	8	1
10	2	5	40	8	13
11	2	17	41	8	25
12	2	30	42	8	43
13	2	42	43	8	55
14	2	55	44	9	7
15	3	7	45	9	19
16	3	19	46	9	31
17	3	32	47	9	43
18	3	44	48	9	55
19	3	57	49	10	7
20	4	9	50	10	19
21	4	22	51	10	31
22	4	34	52	10	43
23	4	47	53	10	55
24	4	59	54	11	7
25	5	11	55	11	19
26	5	24	56	11	31
27	5	36	57	11	43
28	5	48	58	11	55
29	6	1	59	12	7
30	6	13	60	12	19

Equations of Jupiter's Centre.

Argument. Jupiter's Mean Anomaly.

S.	— 0	— 1	— 2	S.
°	° ′ ″	° ′ ″	° ′ ″	°
0	0 0 0	2 37 29	4 38 22	30
1	0 5 28	2 42 17	4 41 23	29
2	0 10 55	2 47 3	4 44 19	28
3	0 16 22	2 51 47	4 47 10	27
4	0 21 49	2 56 28	4 49 57	26
5	0 27 16	3 1 6	4 52 39	25
6	0 32 42	3 5 41	4 55 15	24
7	0 38 8	3 10 13	4 57 46	23
8	0 43 33	3 14 42	5 0 12	22
9	0 48 57	3 19 9	5 2 33	21
10	0 54 21	3 23 33	5 4 50	20
11	0 59 44	3 27 54	5 7 1	19
12	1 5 5	3 32 11	5 9 7	18
13	1 10 26	3 36 24	5 11 7	17
14	1 15 46	3 40 34	5 13 2	16
15	1 21 4	3 44 40	5 14 52	15
16	1 26 21	3 48 43	5 16 36	14
17	1 31 37	3 52 42	5 18 15	13
18	1 36 52	3 56 37	5 19 48	12
19	1 42 5	4 0 28	5 21 15	11
20	1 47 17	4 4 16	5 22 37	10
21	1 52 27	4 8 0	5 23 54	9
22	1 57 35	4 11 40	5 25 5	8
23	2 2 41	4 15 15	5 26 10	7
24	2 7 45	4 18 46	5 27 10	6
25	2 12 47	4 22 13	5 28 4	5
26	2 17 48	4 25 36	5 28 51	4
27	2 22 47	4 28 54	5 29 32	3
28	2 27 44	4 32 8	5 30 7	2
29	2 32 38	4 35 17	5 30 36	1
30	2 37 29	4 38 22	5 31 0	0
S.	+ 11	+ 10	+ 9	S.

Equations of Jupiter's Centre.

Argument. Jupiter's Mean Anomaly.

S.	— 3	— 4	— 5	S.
°	° ′ ″	° ′ ″	° ′ ″	°
0	5 31 0	4 55 40	2 54 48	30
1	5 31 18	4 52 55	2 49 36	29
2	5 31 30	4 50 4	2 44 20	28
3	5 31 36	4 47 8	2 39 0	27
4	5 31 36	4 44 6	2 33 36	26
5	5 31 30	4 40 59	2 28 9	25
6	5 31 18	4 37 46	2 22 39	24
7	5 31 0	4 34 27	2 17 6	23
8	5 30 35	4 31 2	2 11 30	22
9	5 30 4	4 27 32	2 5 51	21
10	5 29 27	4 23 56	2 0 9	20
11	5 28 44	4 20 15	1 54 26	19
12	5 27 55	4 16 29	1 48 40	18
13	5 27 0	4 12 37	1 42 51	17
14	5 25 58	4 8 40	1 37 0	16
15	5 24 50	4 4 38	1 31 6	15
16	5 23 36	4 0 32	1 25 10	14
17	5 22 16	3 56 21	1 19 12	13
18	5 20 50	3 52 4	1 13 13	12
19	5 19 17	3 47 42	1 7 13	11
20	5 17 39	3 43 15	1 1 11	10
21	5 15 55	3 38 44	0 55 8	9
22	5 14 5	3 34 9	0 49 3	8
23	5 12 8	3 29 29	0 42 58	7
24	5 10 4	3 24 44	0 36 52	6
25	5 7 54	3 19 55	0 30 45	5
26	5 5 39	3 15 2	0 24 37	4
27	5 3 18	3 10 5	0 18 28	3
28	5 0 52	3 5 3	0 12 19	2
29	4 58 19	2 59 57	0 6 10	1
30	4 55 40	2 54 48	0 0 0	0
S.	+ 8	+ 7	+ 6	S.

Logarithms of Jupiter's Distance from the Sun.

Argument. Jupiter's Mean Anomaly.

S.	0	1	2	S.
0°	5·736537	5·734080	5·727144	30°
1	5·736534	5·733916	5·726848	29
2	5·736526	5·733747	5·726549	28
3	5·736512	5·733573	5·726247	27
4	5·736493	5·733394	5·725942	26
5	5·736468	5·733210	5·725633	25
6	5·736437	5·733021	5·725321	24
7	5·736401	5·732827	5·725006	23
8	5·736360	5·732629	5·724688	22
9	5·736313	5·732426	5·724367	21
10	5·736260	5·732218	5·724043	20
11	5·736202	5·732006	5·723716	19
12	5·736139	5·731789	5·723386	18
13	5·736070	5·731567	5·723053	17
14	5·735996	5·731341	5·722718	16
15	5·735916	5·731110	5·722382	15
16	5·735831	5·730875	5·722043	14
17	5·735740	5·730635	5·721701	13
18	5·735644	5·730391	5·721357	12
19	5·735542	5·730143	5·721011	11
20	5·735435	5·729890	5·720663	10
21	5·735324	5·729633	5·720313	9
22	5·735207	5·729372	5·719961	8
23	5·735084	5·729107	5·719607	7
24	5·734956	5·728838	5·719252	6
25	5·734823	5·728565	5·718895	5
26	5·734685	5·728288	5·718536	4
27	5·734541	5·728008	5·718177	3
28	5·734392	5·727724	5·717816	2
29	5·734238	5·727436	5·717455	1
30	5·734080	5·727144	5·717093	0
	11	10	9	

Logarithms of Jupiter's Distances from the Sun.

Argument. Jupiter's Mean Anomaly.

S.	3	4	5	S.
0°	5.717093	5.706290	5.697840	30°
1	5.716729	5.705952	5.697636	29
2	5.716364	5.705616	5.697438	28
3	5.715999	5.705284	5.697246	27
4	5.715633	5.704955	5.697060	26
5	5.715266	5.704630	5.696880	25
6	5.714899	5.704307	5.696707	24
7	5.714532	5.703988	5.696540	23
8	5.714165	5.703672	5.696380	22
9	5.713798	5.703360	5.696227	21
10	5.713431	5.703052	5.696080	20
11	5.713064	5.702748	5.695940	19
12	5.712697	5.702447	5.695807	18
13	5.712331	5.702150	5.695680	17
14	5.711965	5.701857	5.695560	16
15	5.711600	5.701569	5.695447	15
16	5.711236	5.701286	5.695342	14
17	5.710873	5.701007	5.695244	13
18	5.710511	5.700732	5.695152	12
19	5.710150	5.700462	5.695067	11
20	5.709791	5.700197	5.694990	10
21	5.709433	5.699938	5.694920	9
22	5.709076	5.699683	5.694858	8
23	5.708720	5.699433	5.694803	7
24	5.708366	5.699189	5.694755	6
25	5.708014	5.698950	5.694713	5
26	5.707665	5.698716	5.694680	4
27	5.707318	5.698488	5.694655	3
28	5.706973	5.698266	5.694637	2
29	5.706630	5.698050	5.694626	1
30	5.706290	5.697840	5.694622	0
	8	7	6	

The Inclination of Jupiter's Orbit, its Reduction to the Ecliptic, and the Logarithm of Curtation.

Argument. Heliocentric Long. — the Long. of the ☊.

	S. + 0 S. — 6 Inclination.	Reduc. —	Log. Curt.	+ 1 — 7 Inclination.	Reduc. —	Log. Curt.	
°	° ′ ″	″		° ′ ″	″		°
0	0 0 0	0	0	0 39 35	24	29	30
1	0 1 23	1	0	0 40 46	24	30	29
2	0 2 46	2	0	0 41 57	25	32	28
3	0 4 9	3	0	0 43 7	25	34	27
4	0 5 31	4	0	0 44 16	25	36	26
5	0 6 54	5	1	0 45 24	26	38	25
6	0 8 16	6	1	0 46 32	26	40	24
7	0 9 39	7	2	0 47 9	26	42	23
8	0 11 1	8	2	0 48 44	26	44	22
9	0 12 23	8	3	0 49 49	27	46	21
10	0 13 45	9	3	0 50 53	27	48	20
11	0 15 6	10	4	0 51 56	27	50	19
12	0 16 27	11	5	0 52 58	27	52	18
13	0 17 48	12	6	0 53 59	27	53	17
14	0 19 9	13	7	0 55 0	27	55	16
15	0 20 29	14	8	0 55 59	27	57	15
16	0 21 49	14	9	0 56 57	27	59	14
17	0 23 9	15	10	0 57 54	27	61	13
18	0 24 28	16	11	0 58 50	27	64	12
19	0 25 46	17	12	0 59 45	27	66	11
20	0 27 5	18	13	1 0 39	27	68	10
21	0 28 22	18	15	1 1 31	27	69	9
22	0 29 39	19	16	1 2 23	26	71	8
23	0 30 56	20	18	1 3 13	26	73	7
24	0 32 12	20	19	1 4 3	26	75	6
25	0 33 27	21	20	1 4 51	26	77	5
26	0 34 42	22	22	1 5 38	25	79	4
27	0 35 56	22	24	1 6 24	25	81	3
28	0 37 10	23	25	1 7 8	25	83	2
29	0 38 23	23	27	1 7 52	24	85	1
30	0 39 35	24	29	1 8 34	24	86	0
	S. — 11 S. + 5	+		— 10 + 4	+		

The Inclination of Jupiter's Orbit, its Reduction to the Ecliptic, and the Logarithm of Curtation.

Argument. Heliocentric Long. — the Long. of the ☊.

	+ 2 S. — 8 S. Inclination.			Reduct. —	Log. Curt.	
°	°	′	″	″		°
0	1	8	34	24	86	30
1	1	9	14	23	88	29
2	1	9	54	23	90	28
3	1	10	32	22	91	27
4	1	11	9	22	93	26
5	1	11	45	21	94	25
6	1	12	19	20	96	24
7	1	12	52	20	97	23
8	1	13	24	19	99	22
9	1	13	54	18	100	21
10	1	14	23	18	102	20
11	1	14	51	17	103	19
12	1	15	17	16	104	18
13	1	15	42	15	105	17
14	1	16	6	14	106	16
15	1	16	28	14	107	15
16	1	16	49	13	108	14
17	1	17	8	12	109	13
18	1	17	26	11	110	12
19	1	17	43	10	111	11
20	1	17	58	9	112	10
21	1	18	11	8	112	9
22	1	18	24	8	113	8
23	1	18	35	7	113	7
24	1	18	44	6	114	6
25	1	18	52	5	114	5
26	1	18	58	4	114	4
27	1	19	3	3	115	3
28	1	19	7	2	115	2
29	1	19	9	1	115	1
30	1	19	10	0	115	0
	— 9 S. + 3 S.			+		

TABLES of SATURN's MOTIONS.

Saturn's Mean Motions in Current Years.

Years.	Longitude.				Apogee.				Node.			
A. D.	S.	°	′	″	S.	°	′	″	S.	°	′	″
1761	0	5	15	59	9	0	12	0	3	21	36	47
1781	8	9	53	11	9	0	42	0	3	21	46	47
1791	0	12	10	46	9	0	57	0	3	21	51	47
B 1792	0	24	24	7	9	0	58	30	3	21	52	17
1793	1	6	39	29	9	1	0	0	3	21	52	47
1794	1	18	52	50	9	1	1	30	3	21	53	17
1795	2	1	6	11	9	1	3	0	3	21	53	47
B 1796	2	13	19	32	9	1	4	30	3	21	54	17
1797	2	25	34	54	9	1	5	0	3	21	54	47
1798	3	7	48	15	9	1	6	30	3	21	55	17
1799	3	20	1	41	9	1	8	0	3	21	55	47
1800	4	2	15	8	9	1	9	30	3	21	56	17
1801	4	14	28	34	9	1	11	0	3	21	56	47
1802	4	26	42	1	9	1	12	30	3	21	57	17
1803	5	8	55	27	9	1	14	0	3	21	57	47
B 1804	5	21	10	55	9	1	15	30	3	21	58	17
1805	6	3	14	21	9	1	17	0	3	21	58	47
1806	6	15	37	48	9	1	18	30	3	21	59	17
1807	6	27	51	14	9	1	20	0	3	21	59	47
B 1808	7	10	6	41	9	1	21	30	3	22	0	17
1809	7	22	20	8	9	1	23	0	3	22	0	47
1810	8	4	33	34	9	1	24	30	3	22	1	17
1811	8	16	47	1	9	1	26	0	3	22	1	47
B 1812	8	29	2	28	9	1	27	30	3	22	2	17
1813	9	11	15	55	9	1	29	0	3	22	2	47
1814	9	23	29	21	9	1	30	30	3	22	3	17
1815	10	5	42	48	9	1	32	0	3	22	3	47
B 1816	10	17	58	15	9	1	33	30	3	22	4	17
1817	11	0	11	41	9	1	35	0	3	22	4	47
1818	11	12	25	8	9	1	36	30	3	22	5	17
1819	11	24	38	35	9	1	38	0	3	22	5	47
B 1820	0	6	54	2	9	1	39	30	3	22	6	17
1821	0	19	7	29	9	1	31	0	3	22	6	47
1841	8	23	46	41	9	2	1	0	3	22	16	47

The Mean Motions of Saturn in Julian Years.

Years.		Longitude.				Apogee.			Node.	
		S.	°	′	″	°	′	″	′	″
	1	0	12	13	37	0	1	6	0	32
	2	0	24	27	14	0	2	12	1	3
	3	1	6	40	50	0	3	18	1	35
B	4	1	18	56	28	0	4	24	2	6
	5	2	1	10	5	0	5	30	2	38
	6	2	13	23	41	0	6	36	3	9
	7	2	25	37	18	0	7	42	3	41
B	8	3	7	52	56	0	8	49	4	12
	9	3	20	6	32	0	9	55	4	44
	10	4	2	20	9	0	11	1	5	16
	11	4	14	33	46	0	12	7	5	47
B	12	4	26	49	24	0	13	13	6	19
	13	5	9	3	0	0	14	19	6	50
	14	5	21	16	37	0	15	25	7	22
	15	6	3	30	14	0	16	31	7	53
B	16	6	15	45	51	0	17	37	8	25
	17	6	27	59	28	0	18	43	8	56
	18	7	10	13	5	0	19	49	9	28
	19	7	22	26	42	0	20	55	9	59
B	20	8	4	42	19	0	22	1	10	31
B	40	4	9	24	39	0	44	3	21	2
B	60	0	14	6	58	1	6	4	31	33
B	80	8	18	49	17	1	28	6	42	4
B	100	4	23	31	36	1	50	7	52	35

The Mean Motions of Saturn in Months.

	Longitude.			Apo.	Node
	°	′	″	″	″
January	0	0	0	0	0
Feb.	1	2	18	6	3
March	1	58	35	10	5
April	3	0	53	17	8
May	4	1	11	21	10
June	5	3	30	27	13
July	6	3	47	33	16
Auguſt	7	6	6	39	18
Sept.	8	8	24	44	21
Octob.	9	8	42	49	24
Novem.	10	11	1	55	26
Decem.	11	11	18	60	29

In January and February of biſſextile years take away a day from the time.

Saturn's Mean Motions in Days.

Days	Longitude.			Apo.	Node
	°	′	″	″	″
1	0	2	1	0	0
2	0	4	1	0	0
3	0	6	2	1	0
4	0	8	2	1	0
5	0	10	3	1	0
6	0	12	4	1	1
7	0	14	4	1	1
8	0	16	5	2	1
9	0	18	5	2	1
10	0	20	6	2	1
11	0	22	6	2	1
12	0	24	7	2	1
13	0	26	8	2	1
14	0	28	8	3	1
15	0	30	9	3	1
16	0	32	9	3	1
17	0	34	10	3	1
18	0	36	11	3	2
19	0	38	11	4	2
20	0	40	12	4	2
21	0	42	12	4	2
22	0	44	13	4	2
23	0	46	14	4	2
24	0	48	14	4	2
25	0	50	15	5	2
26	0	52	15	5	2
27	0	54	16	5	2
28	0	56	17	5	2
29	0	58	17	5	3
30	1	0	18	6	3
31	1	2	18	6	3

Saturn's Mean Motions in Hours and Minutes.

H.	′	″	‴	′	″	′	″	‴
1	0	5		31		2	35	
2	0	10		32		2	40	
3	0	15		33		2	45	
4	0	20		34		2	50	
5	0	25		35		2	55	
6	0	30		36		3	0	
7	0	35		37		3	5	
8	0	40		38		3	10	
9	0	45		39		3	15	
10	0	50		40		3	20	
11	0	55		41		3	25	
12	1	0		42		3	30	
13	1	5		43		3	35	
14	1	10		44		3	40	
15	1	15		45		3	45	
16	1	20		46		3	50	
17	1	25		47		3	55	
18	1	30		48		4	0	
19	1	35		49		4	5	
20	1	40		50		4	10	
21	1	45		51		4	15	
22	1	50		52		4	20	
23	1	55		53		4	25	
24	2	0		54		4	30	
25	2	5		55		4	35	
26	2	10		56		4	40	
27	2	15		57		4	45	
28	2	20		58		4	50	
29	2	25		59		4	55	
30	2	30		60		5	0	

Saturn's Equations.

Argument. Saturn's Mean Anomaly.

S.	— 0	— 1	— 2	S.
°	° ′ ″	° ′ ″	° ′ ″	°
0	0 0 0	3 4 27	5 27 13	30
1	0 6 23	3 10 6	5 30 49	29
2	0 12 46	3 15 43	5 34 19	28
3	0 19 9	3 21 16	5 37 43	27
4	0 25 31	3 26 47	5 41 2	26
5	0 31 53	3 32 14	5 44 15	25
6	0 38 15	3 37 39	5 47 22	24
7	0 44 36	3 42 59	5 50 23	23
8	0 50 56	3 48 16	5 53 19	22
9	0 57 16	3 53 29	5 56 9	21
10	1 3 34	3 58 40	5 58 53	20
11	1 9 52	4 3 46	6 1 31	19
12	1 16 9	4 8 49	6 4 2	18
13	1 22 25	4 13 48	6 6 27	17
14	1 28 39	4 18 43	6 8 47	16
15	1 34 52	4 23 33	6 11 0	15
16	1 41 4	4 28 20	6 13 6	14
17	1 47 14	4 33 2	6 15 7	13
18	1 53 23	4 37 41	6 17 1	12
19	1 59 30	4 42 14	6 18 48	11
20	2 5 35	4 46 44	6 20 28	10
21	2 11 38	4 51 8	6 22 2	9
22	2 17 40	4 55 29	6 23 30	8
23	2 23 39	4 59 45	6 24 51	7
24	2 29 36	5 3 55	6 26 5	6
25	2 35 31	5 8 1	6 27 12	5
26	2 41 23	5 12 2	6 28 12	4
27	2 47 13	5 15 58	6 29 5	3
28	2 53 0	5 19 49	6 29 52	2
29	2 58 45	5 23 34	6 30 31	1
30	3 4 27	5 27 13	6 31 3	0
S.	+ 11	+ 10	+ 9	S.

Saturn's Equations.

Argument. Saturn's Mean Anomaly.

S.	— 3	— 4	— 5	S.
°	° ′ ″	° ′ ″	° ′ ″	°
0	6 31 3	5 51 18	3 28 41	30
1	6 31 29	5 48 6	3 22 29	29
2	6 31 48	5 44 47	2 16 12	28
3	6 32 0	5 41 22	3 9 51	27
4	6 32 4	5 37 50	3 3 26	26
5	6 32 1	5 34 10	2 56 57	25
6	6 31 51	5 30 23	2 50 24	24
7	6 31 33	5 26 30	2 43 47	23
8	6 31 8	5 22 30	2 37 7	22
9	6 30 36	5 18 23	2 30 23	21
10	6 29 58	5 14 10	2 23 35	20
11	6 29 11	5 9 50	2 16 44	19
12	6 28 17	5 5 24	2 9 52	18
13	6 27 16	5 0 51	2 2 54	17
14	6 26 8	4 56 12	1 55 55	16
15	6 24 52	4 51 26	1 48 53	15
16	6 23 29	4 46 35	1 41 49	14
17	6 21 58	4 41 38	1 34 43	13
18	6 20 20	4 36 35	1 27 34	12
19	6 18 35	4 31 26	1 10 23	11
20	6 16 43	4 26 10	1 13 10	10
21	6 14 42	4 20 49	1 5 56	9
22	6 12 35	4 15 22	0 58 40	8
23	6 10 21	4 9 49	0 51 23	7
24	6 8 0	4 4 11	0 44 5	6
25	6 5 31	3 58 29	0 36 46	5
26	6 2 55	3 52 42	0 29 25	4
27	6 0 11	3 46 49	0 22 4	3
28	5 57 21	3 40 51	0 14 43	2
29	5 54 23	3 34 48	0 7 22	1
30	5 51 18	3 28 41	0 0 0	0
S.	+ 8	+ 7	+ 6	S.

Logarithms of Saturn's Distances from the Sun.

Argument. Saturn's Mean Anomaly.

S.	0	1	2	S.
0°	6.003628	6.000791	5.992741	30°
1	6.003625	6.000601	5.992397	29
2	6.003615	6.000406	5.992048	28
3	6.003599	6.000205	5.991696	27
4	6.003577	5.999998	5.991340	26
5	6.003548	5.999786	5.990979	25
6	6.003513	5.999568	5.990615	24
7	6.003471	5.999344	5.990247	23
8	6.003424	5.999114	5.989875	22
9	6.003369	5.998878	5.989500	21
10	6.003309	5.998637	5.989122	20
11	6.003242	5.998390	5.988739	19
12	6.003170	5.998138	5.988353	18
13	6.003090	5.997882	5.987964	17
14	6.003004	5.997620	5.987572	16
15	6.002911	5.997351	5.987177	15
16	6.002813	5.997078	5.986779	14
17	6.002708	5.996800	5.986378	13
18	6.002598	5.996517	5.985975	12
19	6.002481	5.996229	5.985570	11
20	6.002358	5.995935	5.985161	10
21	6.002229	5.995637	5.984750	9
22	6.002094	5.995334	5.984336	8
23	6.001952	5.995026	5.983920	7
24	6.001804	5.994713	5.983502	6
25	6.001650	5.994396	5.983082	5
26	6.001490	5.994074	5.982660	4
27	6.001324	5.993747	5.982237	3
28	6.001152	5.993416	5.981812	2
29	6.000974	5.993081	5.981386	1
30	6.000791	5.992741	5.980957	0
	11	10	9	

Logarithms of Saturn's Distances from the Sun.

Argument. Saturn's Mean Anomaly.

S.	3	4	5	S.
0°	5·980957	5·968128	5·957965	30°
1	5·980528	5·967724	5·957718	29
2	5·980098	5·967323	5·957478	28
3	5·979667	5·966926	5·957245	27
4	5·979234	5·966532	5·957020	26
5	5·978801	5·966141	5·956803	25
6	5·978368	5·965754	5·956593	24
7	5·977934	5·965371	5·956391	23
8	5·977499	5·964992	5·956197	22
9	5·977064	5·964617	5·956010	21
10	5·976629	5·964247	5·955832	20
11	5·976194	5·963881	5·955662	19
12	5·975760	5·963520	5·955500	18
13	5·975326	5·963163	5·955347	17
14	5·974892	5·962811	5·955202	16
15	5·974459	5·962465	5·955065	15
16	5·974026	5·962123	5·954937	14
17	5·973594	5·961787	5·954817	13
18	5·973163	5·961456	5·954706	12
19	5·972734	5·961131	5·954604	11
20	5·972306	5·960812	5·954510	10
21	5·971879	5·960499	5·954425	9
22	5·971454	5·960191	5·954349	8
23	5·971031	5·959890	5·954282	7
24	5·970609	5·959595	5·954224	6
25	5·970189	5·959306	5·954174	5
26	5·969772	5·959025	5·954134	4
27	5·969357	5·958749	5·954103	3
28	5·968945	5·958481	5·954080	2
29	5·968535	5·958219	5·954067	1
30	5·968128	5·957965	5·954062	0
	8	7	6	

The Inclination of Saturn's Orbit, its Reduction to the Ecliptic, and the Logarithm of Curtation.

Argument. Heliocentric Long. — the Long. of the ☊.

	S. + 0 S. — 6 Inclination.			Reduc. —		Log. Curt.	+ 1 — 7 Inclination.			Reduc. —		Log. Curt.	
°	°	′	″	′	″		°	′	″	′	″		°
0	0	0	0	0	0	0	1	15	4	1	25	103	30
1	0	2	37	0	4	0	1	17	19	1	26	110	29
2	0	5	14	0	8	1	1	19	33	1	27	116	28
3	0	7	51	0	11	1	1	21	46	1	29	123	27
4	0	10	28	0	15	2	1	23	58	1	31	129	26
5	0	13	5	0	18	3	1	26	7	1	32	136	25
6	0	15	41	0	21	5	1	28	15	1	33	143	24
7	0	18	18	0	24	6	1	30	21	1	34	150	23
8	0	20	53	0	27	8	1	32	26	1	35	157	22
9	0	23	29	0	31	10	1	34	29	1	35	164	21
10	0	26	4	0	34	12	1	36	30	1	36	171	20
11	0	28	39	0	37	15	1	38	30	1	36	178	19
12	0	31	13	0	41	18	1	40	28	1	37	185	18
13	0	33	46	0	44	21	1	42	24	1	37	192	17
14	0	36	19	0	47	24	1	44	18	1	38	200	16
15	0	38	51	0	49	28	1	46	10	1	38	207	15
16	0	41	23	0	52	32	1	48	0	1	38	214	14
17	0	43	54	0	55	36	1	49	48	1	38	221	13
18	0	46	24	0	58	40	1	51	35	1	37	228	12
19	0	48	53	1	1	44	1	53	19	1	37	236	11
20	0	51	21	1	3	48	1	55	1	1	36	243	10
21	0	53	48	1	6	53	1	56	41	1	36	250	9
22	0	56	14	1	9	58	1	58	19	1	35	257	8
23	0	58	39	1	11	63	1	59	55	1	35	264	7
24	1	1	4	1	13	68	2	1	29	1	34	271	6
25	1	3	27	1	15	74	2	3	0	1	33	277	5
26	1	5	49	1	17	79	2	4	29	1	32	284	4
27	1	8	9	1	19	85	2	5	56	1	31	291	3
28	1	10	29	1	21	91	2	7	20	1	29	297	2
29	1	12	47	1	23	97	2	8	42	1	27	303	1
30	1	15	4	1	25	103	2	10	2	1	25	310	0
	S. — 11 S. + 5			+			— 10 + 4			+			

The Inclination of Saturn's Orbit, its Reduction to the Ecliptic, and the Logarithm of Curtation.

Argument. Heliocentric Long. — the Long. of the ☊.

	+ 2 S. — 8 S. Inclination.			Reduct. —		Log. Curt.	
°	°	′	″	′	″		°
0	2	10	2	1	25	310	30
1	2	11	20	1	23	316	29
2	2	12	35	1	21	322	28
3	2	13	47	1	19	328	27
4	2	14	58	1	17	334	26
5	2	16	5	1	15	340	25
6	2	17	10	1	13	345	24
7	2	18	13	1	11	350	23
8	2	19	13	1	9	355	22
9	2	20	11	1	6	360	21
10	2	21	6	1	3	365	20
11	2	21	59	1	1	370	19
12	2	22	49	0	58	374	18
13	2	23	36	0	55	378	17
14	2	24	21	0	52	382	16
15	2	25	3	0	49	386	15
16	2	25	42	0	47	389	14
17	2	26	19	0	44	393	13
18	2	26	53	0	41	396	12
19	2	27	24	0	37	399	11
20	2	27	53	0	34	401	10
21	2	28	19	0	31	403	9
22	2	28	42	0	27	406	8
23	2	29	3	0	24	408	7
24	2	29	21	0	21	409	6
25	2	29	36	0	18	410	5
26	2	29	48	0	15	411	4
27	2	29	57	0	11	412	3
28	2	30	4	0	8	413	2
29	2	30	8	0	4	414	1
30	2	30	10	0	0	414	0
	— 9 S. + 3 S.			+			

TABLE I. *Of Mean New Moons, &c. in March, from 1791 to 1821.*

	Mean New Moon in March.				Sun's Mean Anomaly.				Moon's Mean Anomaly.				Sun's Mean Dist. from the Moon's Node.			
A. D	D.	H.	m.	s.	S.	°	′	″	S.	°	′	″	S.	°	′	″
1791	4	14	8	35	8	3	31	47	9	26	23	45	4	18	52	22
1792	22	11	41	15	8	21	53	59	9	2	0	52	5	27	35	24
1793	11	20	29	51	8	11	9	51	7	11	48	57	6	5	38	11
1794	30	18	2	32	8	29	32	3	6	17	26	4	7	14	21	13
1795	20	2	51	8	8	18	47	55	4	27	14	9	7	22	24	0
1796	8	11	39	44	8	8	3	47	3	7	2	14	8	0	26	47
1797	27	9	12	24	8	26	25	59	2	12	39	19	9	9	9	48
1798	16	18	1	1	8	15	41	51	0	22	27	25	9	17	12	35
1799	6	2	49	37	8	4	57	43	11	2	15	30	9	25	15	22
1800	25	0	22	17	8	23	19	55	10	7	52	36	11	3	58	23
1801	14	9	10	53	8	12	35	47	8	17	40	41	11	12	1	10
1802	3	17	59	29	8	1	51	39	6	27	28	46	11	20	3	57
1803	22	15	32	9	8	20	13	51	6	3	5	52	0	28	46	58
1804	11	0	20	45	8	9	29	43	4	12	53	57	1	6	49	45
1805	0	9	9	21	7	28	45	31	2	22	42	2	1	14	52	35
1806	19	6	42	1	8	17	7	43	1	28	19	8	2	23	35	36
1807	8	15	30	37	8	6	23	35	0	8	7	13	3	1	38	23
1808	26	13	3	17	8	24	45	47	11	13	44	19	4	10	21	24
1809	15	21	51	53	8	14	1	39	9	23	32	24	4	18	24	11
1810	5	6	40	29	8	3	17	31	8	3	20	29	4	26	26	58
1811	24	4	13	9	8	21	39	43	7	8	57	35	6	5	9	59
1812	12	13	1	45	8	10	55	35	5	18	45	40	6	13	12	46
1813	1	21	50	21	8	0	11	27	3	28	33	45	6	21	15	23
1814	20	19	23	1	8	18	33	39	3	4	10	51	7	29	58	24
1815	10	4	11	37	8	7	53	31	1	13	58	56	8	8	1	11
1816	28	1	44	17	8	26	15	43	0	19	36	2	9	16	44	12
1817	17	10	32	53	8	15	31	35	10	29	24	7	9	24	46	59
1818	6	19	21	29	8	4	47	27	9	9	12	12	10	2	49	46
1819	25	16	54	9	8	23	9	39	8	14	49	18	11	11	32	47
1820	14	1	42	45	8	12	25	31	6	24	37	23	11	19	35	34
1821	3	10	31	21	8	1	41	23	5	4	25	28	11	27	38	21

II. *Mean Anomalies, and Sun's Mean Distance from the Node, for* $13\frac{1}{2}$ *Mean Lunations.*

	Mean Lunations.				Sun's Mean Anomaly.				Moon's Mean Anomaly.				Sun's Mean Dist. from the Node.			
N°	D.	H.	m.	s.	S.	°	′	″	S.	°	′	″	S.	°	′	″
1	29	12	44	3	0	29	6	19	0	25	49	0	1	0	40	14
2	59	1	28	6	1	28	12	39	1	21	38	1	2	1	20	28
3	88	14	12	9	2	27	18	58	2	17	27	1	3	2	0	42
4	118	2	56	12	3	26	25	17	3	13	16	2	4	2	40	56
5	147	15	40	15	4	25	31	37	4	9	5	2	5	3	21	10
6	177	4	24	18	5	24	37	56	5	4	54	3	6	4	1	24
7	206	17	8	21	6	23	44	15	6	0	43	3	7	4	41	38
8	236	5	52	24	7	22	50	35	6	26	32	3	8	5	21	53
9	265	18	36	27	8	21	56	54	7	22	21	4	9	6	2	6
10	295	7	20	30	9	21	3	14	8	18	10	4	10	6	42	20
11	324	20	4	33	10	20	9	33	9	13	59	5	11	7	22	34
12	354	8	48	36	11	19	15	52	10	9	48	5	0	8	2	47
13	383	21	32	40	0	18	22	12	11	5	37	6	1	8	43	1
$\frac{1}{2}$	14	18	22	2	0	14	33	10	6	12	54	30	0	15	20	7

III. *The Days of the Year, reckoned from the beginning of March.*

Days.	March.	April.	May.	June.	July.	Aug.	Sept.	Octob.	Novem.	Decem.	Jan.	Feb.
1	1	32	62	93	123	154	185	215	246	276	307	338
2	2	33	63	94	124	155	186	216	247	277	308	339
3	3	34	64	95	125	156	187	217	248	278	309	340
4	4	35	65	96	126	157	188	218	249	279	310	341
5	5	36	66	97	127	158	189	219	250	280	311	342
6	6	37	67	98	128	159	190	220	251	281	312	343
7	7	38	68	99	129	160	191	221	252	282	313	344
8	8	39	69	100	130	161	192	222	253	283	314	345
9	9	40	70	101	131	162	193	223	254	284	315	346
10	10	41	71	102	132	163	194	224	255	285	316	347
11	11	42	72	103	133	164	195	225	256	286	317	348
12	12	43	73	104	134	165	196	226	257	287	318	349
13	13	44	74	105	135	166	197	227	258	288	319	350
14	14	45	75	106	136	167	198	228	259	289	320	351
15	15	46	76	107	137	168	199	229	260	290	321	352
16	16	47	77	108	138	169	200	230	261	291	322	353
17	17	48	78	109	139	170	201	231	262	292	323	354
18	18	49	79	110	140	171	202	232	263	293	324	355
19	19	50	80	111	141	172	203	233	264	294	325	356
20	20	51	81	112	142	173	204	234	265	295	326	357
21	21	52	82	113	143	174	205	235	266	296	327	358
22	22	53	83	114	144	175	206	236	267	297	328	359
23	23	54	84	115	145	176	207	237	268	298	329	360
24	24	55	85	116	146	177	208	238	269	299	330	361
25	25	56	86	117	147	178	209	239	270	300	331	362
26	26	57	87	118	148	179	210	240	271	301	332	363
27	27	58	88	119	149	180	211	241	272	302	333	364
28	28	59	89	120	150	181	212	242	273	303	334	365
29	29	60	90	121	151	182	213	243	274	304	335	366
30	30	61	91	122	152	183	214	244	275	305	336	
31	31		92		153	184		245		306	337	

IV. *The Annual or First Equation of the Mean to the True Syzygy.*

Argument. Sun's Mean Anomaly.

°	S. 0			1			2			3			4			5			°
	H.	m.	s.	H.	m.	s.	H.	m.	s.	H.	m.	s.	H.	m.	s.	H.	m.	s.	
0	0	0	0	2	3	12	3	35	0	4	10	53	3	39	30	2	7	45	30
1	0	4	18	2	6	55	3	37	10	4	10	57	3	37	19	2	3	55	29
2	0	8	35	2	10	36	3	39	18	4	10	55	3	35	6	2	0	1	28
3	0	12	51	2	14	14	3	41	23	4	10	49	3	32	50	1	56	5	27
4	0	17	8	2	17	52	3	43	26	4	10	39	3	30	30	1	52	6	26
5	0	21	24	2	21	27	3	45	25	4	10	24	3	28	5	1	48	4	25
6	0	25	39	2	25	9	3	47	19	4	10	4	3	25	35	1	41	1	24
7	0	28	55	2	28	29	3	49	7	4	9	39	3	23	0	1	39	56	23
8	0	34	11	2	31	57	3	50	50	4	9	10	3	20	20	1	35	49	22
9	0	38	26	2	35	22	3	52	29	4	8	37	3	17	35	1	31	41	21
10	0	42	39	2	38	44	3	54	4	4	7	59	3	14	49	1	27	31	20
11	0	46	52	2	42	3	3	55	35	4	7	16	3	11	59	1	23	19	19
12	0	51	4	2	45	18	3	57	2	4	6	29	3	9	6	1	19	5	18
13	0	55	17	2	48	30	3	58	27	4	5	37	3	6	10	1	14	49	17
14	0	59	27	2	51	40	3	59	49	4	4	41	3	3	10	1	10	32	16
15	1	3	36	2	54	48	4	1	7	4	3	40	3	0	7	1	6	15	15
16	1	7	45	2	57	53	4	2	18	4	2	35	2	57	0	1	1	56	14
17	1	11	53	3	0	54	4	3	23	4	1	26	2	53	49	0	57	36	13
18	1	16	0	3	3	51	4	4	22	4	0	12	2	50	36	0	53	15	12
19	1	20	6	3	6	45	4	5	18	3	58	52	2	47	18	0	48	52	11
20	1	24	10	3	9	36	4	6	10	3	57	27	2	43	57	0	44	28	10
21	1	28	12	3	12	24	4	6	58	3	55	59	2	40	33	0	40	2	9
22	1	32	12	3	15	9	4	7	41	3	54	26	2	37	6	0	35	36	8
23	1	36	10	3	17	51	4	8	21	3	52	49	2	33	35	0	31	10	7
24	1	40	6	3	20	30	4	8	57	3	51	9	2	30	2	0	26	44	6
25	1	44	1	3	23	5	4	9	29	3	49	26	2	26	26	0	22	17	5
26	1	47	54	3	25	36	4	9	55	3	47	38	2	22	47	0	17	50	4
27	1	51	46	3	28	3	4	10	16	3	45	44	2	19	5	0	13	23	3
28	1	55	37	3	30	26	4	10	33	3	43	45	2	15	20	0	8	56	2
29	1	59	26	3	32	45	4	10	45	3	41	40	2	11	35	0	4	29	1
30	2	3	12	3	35	0	4	10	53	3	39	30	2	7	45	0	0	0	0
	S.	11			10			9			8			7			6		

+

V. *Equation of the Moon's Mean Anomaly.*

Argument. Sun's Mean Anomaly.

	S. 0			1			2			3			4			5			
°	°	′	″	°	′	″	°	′	″	°	′	″	°	′	″	°	′	″	°
0	0	0	0	0	46	45	1	21	32	1	35	1	1	23	4	0	48	19	30
1	0	1	37	0	48	10	1	22	21	1	35	2	1	22	14	0	46	51	29
2	0	3	13	0	49	34	1	23	10	1	35	1	1	21	24	0	45	23	28
3	0	4	52	0	50	53	1	23	57	1	35	0	1	20	32	0	43	54	27
4	0	6	28	0	52	19	1	24	41	1	34	57	1	19	38	0	42	24	26
5	0	8	6	0	53	40	1	25	24	1	34	50	1	18	42	0	40	53	25
6	0	9	42	0	55	0	1	26	6	1	34	43	1	17	45	0	39	21	24
7	0	11	20	0	56	21	1	26	48	1	34	33	1	16	48	0	37	49	23
8	0	12	56	0	57	38	1	27	28	1	34	22	1	15	47	0	36	15	22
9	0	14	33	0	58	56	1	28	6	1	34	9	1	14	44	0	34	40	21
10	0	16	10	1	0	13	1	28	43	1	33	53	1	13	41	0	33	5	20
11	0	17	47	1	1	29	1	29	17	1	33	37	1	12	37	0	31	31	19
12	0	19	23	1	2	43	1	29	51	1	33	20	1	11	33	0	29	54	18
13	0	20	59	1	3	56	1	30	22	1	33	0	1	10	26	0	28	18	17
14	0	22.	35	1	5	8	1	30	50	1	32	38	1	9	17	0	26	40	16
15	0	24	10	1	6	18	1	31	19	1	32	14	1	8	8	0	25	3	15
16	0	25	45	1	7	27	1	31	45	1	31	50	1	6	58	0	23	23	14
17	0	27	19	1	8	36	1	32	12	1	31	23	1	5	46	0	21	45	13
18	0	28	52	1	9	42	1	32	34	1	30	55	1	4	32	0	20	7	12
19	0	30	25	1	10	49	1	32	57	1	30	25	1	3	19	0	18	28	11
20	0	31	57	1	11	54	1	33	17	1	29	54	1	2	1	0	16	48	10
21	0	33	29	1	12	58	1	33	36	1	29	20	1	0	45	0	15	8	9
22	0	35	2	1	14	1	1	33	52	1	28	45	0	59	26	0	13	28	8
23	0	36	32	1	15	1	1	34	6	1	28	9	0	58	7	0	11	48	7
24	0	38	1	1	16	0	1	34	18	1	27	30	0	56	45	0	10	7	6
25	0	39	29	1	16	59	1	34	30	1	26	50	0	55	23	0	8	20	5
26	0	40	59	1	17	57	1	34	40	1	26	27	0	54	1	0	6	44	4
27	0	42	26	1	18	52	1	34	48	1	25	50	0	52	37	0	5	3	3
28	0	43	54	1	19	47	1	34	54	1	24	39	0	51	12	0	3	21	2
29	0	45	19	1	20	40	1	34	58	1	23	52	0	49	45	0	1	40	1
30	0	46	45	1	21	32	1	35	1	1	23	4	0	48	19	0	0	0	0
	S. 11			10			9			8			7			6			

+

VI. *The Second Equation of the Mean to the True Syzygy.*

Argument. Moon's equated Anomaly.

+

°	S. 0			1			2			3			4			5			°
	H.	m.	s.	H.	m.	s.	H.	m.	s.	H.	m.	s.	H.	m.	s.	H.	m.	s.	
0	0	0	0	5	12	48	8	47	8	9	46	44	8	8	59	4	34	33	30
1	0	10	58	5	21	56	8	51	45	9	45	3	8	3	12	4	26	1	29
2	0	21	56	5	30	57	8	56	10	9	45	12	7	57	23	4	17	25	28
3	0	32	54	5	39	51	9	0	25	9	44	11	7	51	33	4	8	47	27
4	0	43	52	5	48	37	9	4	31	9	42	59	7	45	46	4	0	7	26
5	0	54	50	5	57	17	9	8	25	9	41	36	7	39	46	3	51	23	25
6	1	5	48	6	5	51	9	12	9	9	40	3	7	33	36	3	42	32	24
7	1	16	46	6	14	19	9	15	43	9	38	19	7	27	22	3	33	38	23
8	1	27	44	6	22	41	9	19	5	9	36	24	7	21	2	3	24	42	22
9	1	38	40	6	30	57	9	22	14	9	34	18	7	14	30	3	15	44	21
10	1	49	33	6	39	4	9	25	12	9	32	1	7	7	50	3	6	45	20
11	2	0	23	6	47	0	9	27	54	9	29	33	7	1	2	2	57	43	19
12	2	11	10	6	54	46	9	30	32	9	26	54	6	54	8	2	48	39	18
13	2	21	54	7	2	24	9	32	58	9	24	4	6	47	9	2	39	34	17
14	2	32	34	7	9	52	9	35	12	9	21	3	6	40	6	2	30	28	16
15	2	43	9	7	17	9	9	37	14	9	17	51	6	32	56	2	21	19	15
16	2	53	38	7	24	19	9	39	8	9	14	28	6	25	40	2	12	8	14
17	3	4	37	7	31	18	9	40	51	9	10	54	6	18	18	2	2	53	13
18	3	14	24	7	38	9	9	42	21	9	7	9	6	10	49	1	53	36	12
19	3	24	42	7	44	51	9	43	42	9	3	13	6	3	16	1	44	16	11
20	3	34	58	7	51	24	9	44	53	8	59	6	5	55	38	1	34	54	10
21	3	45	11	7	57	45	9	45	52	8	54	50	5	47	54	1	25	31	9
22	3	55	21	8	3	56	9	46	38	8	50	24	5	40	4	1	16	7	8
23	4	5	26	8	9	57	9	47	13	8	45	48	5	32	9	1	6	41	7
24	4	15	26	8	15	46	0	47	36	8	41	2	5	24	9	0	57	13	6
25	4	25	20	8	21	24	9	47	49	8	36	6	5	16	5	0	47	44	5
26	4	35	6	8	26	53	9	47	54	8	31	0	5	7	56	0	38	13	4
27	4	44	42	8	32	11	9	47	46	8	25	44	4	59	42	0	28	41	3
28	4	54	11	8	37	19	9	47	33	8	20	18	4	51	15	0	19	8	2
29	5	3	33	8	42	18	9	47	14	8	14	33	4	43	2	0	9	34	1
30	5	12	48	8	47	8	9	46	44	8	8	59	4	34	33	0	0	0	0
	S.	11			10			9			8			7			6		

VII. *The third Equation of the Mean to the True Syzygy.*

Argument. ☉'s Mean Anom. — ☽'s Mean Anom.

	S. — 0	— 1	— 2	
	S. + 6	+ 7	+ 8	
°	m. s.	m. s.	m. s.	°
0	0 0	2 22	4 12	30
1	0 5	2 26	4 15	29
2	0 10	2 30	4 18	28
3	0 15	2 34	4 21	27
4	0 20	2 38	4 24	26
5	0 25	2 42	4 27	25
6	0 30	2 46	4 30	24
7	0 35	2 50	4 32	23
8	0 40	2 54	4 34	22
9	0 45	2 58	4 36	21
10	0 50	3 2	4 38	20
11	0 55	3 6	4 40	19
12	1 0	3 10	4 42	18
13	1 5	3 14	4 44	17
14	1 10	3 18	4 46	16
15	1 15	3 22	4 48	15
16	1 20	3 26	4 50	14
17	1 25	3 30	4 51	13
18	1 30	3 34	4 52	12
19	1 35	3 38	4 53	11
20	1 40	3 42	4 54	10
21	1 45	3 45	4 55	9
22	1 49	3 48	4 56	8
23	1 52	3 51	4 57	7
24	1 56	3 54	4 57	6
25	2 0	3 57	4 57	5
26	2 4	4 0	4 58	4
27	2 9	4 3	4 58	3
28	2 13	4 6	4 58	2
29	2 18	4 9	4 58	1
30	2 22	4 12	4 58	0
	S. — 5	— 4	— 3 S.	
	S. + 11	+ 10	+ 9 S.	

VIII. *The fourth Equation of the Mean to the True Syzygy.*

Argument. ☉'s Mean Dist. from ☽'s ☊.

	+ 0	+ 1	+ 2	
	+ 6	+ 7	+ 8	
°	m. s.	m. s.	m. s.	°
0	0 0	1 22	1 22	30
1	0 4	1 23	1 21	29
2	0 7	1 24	1 20	28
3	0 10	1 25	1 18	27
4	0 13	1 26	1 16	26
5	0 16	1 27	1 14	25
6	0 20	1 28	1 12	24
7	0 23	1 29	1 10	23
8	0 26	1 30	1 8	22
9	0 29	1 31	1 6	21
10	0 32	1 32	1 3	20
11	0 35	1 33	1 0	19
12	0 38	1 33	0 57	18
13	0 41	1 34	0 54	17
14	0 44	1 34	0 51	16
15	0 47	1 34	0 49	15
16	0 50	1 34	0 45	14
17	0 52	1 34	0 41	13
18	0 54	1 34	0 37	12
19	0 57	1 33	0 34	11
20	1 0	1 33	0 31	10
21	1 2	1 32	0 28	9
22	1 5	1 31	0 25	8
23	1 8	1 30	0 22	7
24	1 10	1 29	0 19	6
25	1 12	1 28	0 16	5
26	1 14	1 27	0 13	4
27	1 16	1 26	0 10	3
28	1 18	1 25	0 6	2
29	1 20	1 24	0 3	1
30	1 22	1 22	0 0	0
	S. — 5	— 4	— 3 S.	
	S. — 11	— 10	— 9 S.	

Table of Logistical Logarithms.

	0	1	2	3	4	5	6	7
	0	60	120	180	240	300	360	420
0	00000	17782	14771	13010	11761	10792	10000	9331
1	35563	17710	14735	12986	11743	10777	9988	9320
2	32553	17639	14699	12962	11725	10763	9976	9310
3	30792	17570	14664	12939	11707	10749	9964	9300
4	29542	17501	14629	12915	11689	10734	9952	9289
5	28573	17434	14594	12891	11671	10720	9940	9279
6	27782	17368	14559	12868	11654	10706	9928	9269
7	27112	17302	14525	12845	11636	10692	9916	9259
8	26532	17238	14491	12821	11619	10678	9905	9249
9	26021	17175	14457	12798	11601	10663	9893	9238
10	25563	17112	14424	12775	11584	10649	9881	9228
11	25149	17050	14390	12753	11566	10635	9869	9218
12	24771	16990	14357	12730	11549	10621	9858	9208
13	24424	16930	14325	12707	11532	10608	9846	9198
14	24102	16871	14292	12685	11515	10594	9834	9188
15	23802	16812	14260	12663	11498	10580	9823	9178
16	23522	16755	14228	12640	11481	10566	9811	9168
17	23259	16698	14196	12618	11464	10552	9800	9158
18	23010	16642	14165	12596	11447	10539	9788	9148
19	22775	16587	14133	12574	11430	10525	9777	9138
20	22553	16532	14102	12553	11413	10512	9765	9128
21	22341	16478	14071	12531	11397	10498	9754	9119
22	22139	16425	14040	12510	11380	10484	9742	9109
23	21946	16372	14010	12488	11363	10471	9731	9099
24	21761	16320	13979	12467	11347	10458	9720	9089
25	21584	16269	13949	12445	11331	10444	9708	9079
26	21413	16218	13919	12424	11314	10431	9697	9070
27	21249	16168	13890	12403	11298	10418	9686	9060
28	21091	16118	13860	12382	11282	10404	9675	9050
29	20939	16069	13831	12362	11266	10391	9664	9041
30	20792	16021	13802	12341	11249	10378	9652	9031

Table of Logistical Logarithms.

	0	1	2	3	4	5	6	7
	0	60	120	180	240	300	360	420
30	20792	16021	13802	12341	11249	10378	9652	9031
31	20649	15973	13773	12320	11233	10365	9641	9021
32	20512	15925	13745	12300	11217	10352	9630	9012
33	20378	15878	13716	12279	11201	10339	9619	9002
34	20248	15832	13688	12259	11186	10326	9608	8992
35	20122	15786	13660	12239	11170	10313	9597	8983
36	20000	15740	13632	12218	11154	10300	9586	8973
37	19881	15695	13604	12198	11138	10287	9575	8964
38	19765	15651	13576	12178	11123	10274	9564	8954
39	19652	15607	13549	12159	11107	10261	9553	8945
40	19542	15563	13522	12139	11091	10248	9542	8935
41	19435	15520	13495	12119	11076	10235	9532	8926
42	19331	15477	13468	12099	11061	10223	9521	8917
43	19228	15435	13441	12080	11045	10210	9510	8907
44	19128	15393	13415	12061	11030	10197	9499	8898
45	19031	15351	13388	12041	11015	10185	9488	8888
46	18935	15310	13362	12022	10999	10172	9478	8879
47	18842	15269	13336	12003	10984	10160	9467	8870
48	18751	15229	13310	11984	10969	10147	9456	8861
49	18661	15189	13284	11965	10954	10135	9446	8851
50	18573	15149	13259	11946	10939	10122	9435	8842
51	18487	15110	13233	11927	10924	10110	9425	8833
52	18403	15071	13208	11908	10909	10098	9414	8824
53	18320	15032	13183	11889	10894	10085	9404	8814
54	18239	14994	13158	11871	10880	10073	9393	8805
55	18159	14956	13133	11852	10865	10061	9383	8796
56	18081	14918	13108	11834	10850	10049	9372	8787
57	18004	14881	13083	11816	10835	10036	9362	8778
58	17929	14844	13059	11797	10821	10024	9351	8769
59	17855	14808	13034	11779	10806	10012	9341	8760
60	17782	14771	13010	11761	10792	10000	9331	8752

Table of Logistical Logarithms.

	8	9	10	11	12	13	14	15	16
	480	540	600	660	720	780	840	900	960
0	8751	8239	7782	7368	6990	6642	6320	6021	5740
1	8742	8231	7774	7361	6984	6637	6315	6016	5736
2	8733	8223	7767	7354	6978	6631	6310	6011	5731
3	8724	8215	7760	7348	6972	6625	6305	6006	5727
4	8715	8207	7753	7341	6966	6620	6300	6001	5722
5	8706	8199	7745	7335	6960	6614	6294	5997	5718
6	8697	8191	7738	7328	6954	6609	6289	5992	5713
7	8688	8183	7731	7322	6948	6603	6284	5987	5709
8	8679	8175	7724	7315	6942	6598	6279	5982	5704
9	8670	8167	7717	7309	6936	6592	6274	5977	5700
10	8661	8159	7710	7302	6930	6587	6269	5973	5695
11	8652	8152	7703	7296	6924	6581	6264	5968	5691
12	8643	8144	7696	7289	6918	6576	6259	5963	5686
13	8635	8136	7688	7283	6912	6570	6254	5958	5682
14	8626	8128	7681	7276	6906	6565	6248	5954	5677
15	8617	8120	7674	7270	6900	6559	6243	5949	5673
16	8608	8112	7667	7264	6894	6554	6238	5944	5669
17	8599	8104	7660	7257	6888	6548	6233	5939	5664
18	8591	8097	7653	7251	6882	6543	6228	5935	5660
19	8582	8089	7646	7244	6877	6538	6223	5930	5655
20	8573	8081	7639	7238	6871	6532	6218	5925	5651
21	8565	8073	7632	7232	6865	6527	6213	5920	5646
22	8556	8066	7625	7225	6859	6521	6208	5916	5642
23	8547	8058	7618	7219	6853	6516	6203	5911	5637
24	8539	8050	7611	7212	6847	6510	6198	5906	5633
25	8530	8043	7604	7206	6841	6505	6193	5902	5629
26	8522	8035	7597	7200	6836	6500	6188	5897	5624
27	8513	8027	7590	7193	6830	6494	6183	5892	5620
28	8504	8020	7583	7187	6824	6489	6178	5888	5615
29	8496	8012	7577	7181	6818	6484	6173	5883	5611
30	8487	8004	7570	7175	6812	6478	6168	5878	5607

Table of Logistical Logarithms.

	8	9	10	11	12	13	14	15	16
	480	540	600	660	720	780	840	900	960
30	8487	8004	7570	7175	6812	6478	6168	5878	5607
31	8479	7997	7563	7168	6807	6473	6163	5874	5602
32	8470	7989	7556	7162	6801	6467	6158	5869	5598
33	8462	7981	7549	7156	6795	6462	6153	5864	5594
34	8453	7974	7542	7149	6789	6457	6148	5860	5589
35	8445	7966	7535	7143	6784	6451	6143	5855	5585
36	8437	7959	7528	7137	6778	6446	6138	5850	5580
37	8428	7951	7522	7131	6772	6441	6133	5846	5576
38	8420	7944	7515	7124	6766	6435	6128	5841	5572
39	8411	7936	7508	7118	6761	6430	6123	5836	5567
40	8403	7929	7501	7112	6755	6425	6118	5832	5563
41	8395	7921	7494	7106	6749	6420	6113	5827	5559
42	8386	7914	7488	7100	6743	6414	6108	5823	5554
43	8378	7906	7481	7093	6738	6409	6103	5818	5550
44	8370	7899	7474	7087	6732	6404	6099	5813	5546
45	8361	7891	7467	7081	6726	6398	6094	5809	5541
46	8353	7884	7461	7075	6721	6393	6089	5804	5537
47	8345	7877	7454	7069	6715	6388	6084	5800	5533
48	8337	7869	7447	7063	6709	6383	6079	5795	5528
49	8328	7862	7441	7057	6704	6377	6074	5790	5524
50	8320	7855	7434	7050	6698	6372	6069	5786	5520
51	8312	7847	7427	7044	6692	6367	6064	5781	5516
52	8304	7840	7421	7038	6687	6362	6059	5777	5511
53	8296	7832	7414	7032	6681	6357	6055	5772	5507
54	8288	7825	7407	7026	6676	6351	6050	5768	5503
55	8279	7818	7401	7020	6670	6346	6045	5763	5498
56	8271	7811	7394	7014	6664	6341	6040	5758	5494
57	8263	7803	7387	7008	6659	6336	6035	5754	5490
58	8255	7796	7381	7002	6653	6331	6030	5749	5486
59	8247	7789	7374	6996	6648	6325	6025	5745	5481
60	8239	7782	7368	6990	6642	6320	6021	5740	5477

Table of Logistical Logarithms.

	17	18	19	20	21	22	23	24	25
	1020	1080	1140	1200	1260	1320	1380	1440	1500
0	5477	5229	4994	4771	4559	4357	4164	3979	3802
1	5473	5225	4990	4768	4556	4354	4161	3976	3799
2	5469	5221	4986	4764	4552	4351	4158	3973	3796
3	5464	5217	4983	4760	4549	4347	4155	3970	3793
4	5460	5213	4979	4757	4546	4344	4152	3967	3791
5	5456	5209	4975	4753	4542	4341	4149	3964	3788
6	5452	5205	4971	4750	4539	4338	4145	3961	3785
7	5447	5201	4967	4746	4535	4334	4142	3958	3782
8	5443	5197	4964	4742	4532	4331	4139	3955	3779
9	5439	5193	4960	4739	4528	4328	4136	3952	3776
10	5435	5189	4956	4735	4525	4325	4133	3949	3773
11	5430	5185	4952	4732	4522	4321	4130	3946	3770
12	5426	5181	4949	4728	4518	4318	4127	3943	3768
13	5422	5177	4945	4724	4515	4315	4124	3940	3765
14	5418	5173	4941	4721	4511	4311	4120	3937	3762
15	5414	5169	4937	4717	4508	4308	4117	3934	3759
16	5409	5165	4933	4714	4505	4305	4114	3931	3756
17	5405	5161	4930	4710	4501	4302	4111	3928	3753
18	5401	5157	4926	4707	4498	4298	4108	3925	3750
19	5397	5153	4922	4703	4494	4295	4105	3922	3747
20	5393	5149	4918	4699	4491	4292	4102	3919	3745
21	5389	5145	4915	4696	4488	4289	4099	3917	3742
22	5384	5141	4911	4692	4484	4285	4096	3914	3739
23	5380	5137	4907	4689	4481	4282	4092	3911	3736
24	5376	5133	4903	4685	4477	4279	4089	3908	3733
25	5372	5129	4900	4682	4474	4276	4086	3905	3730
26	5368	5125	4896	4678	4471	4273	4083	3902	3727
27	5364	5122	4892	4675	4467	4269	4080	3899	3725
28	5359	5118	4889	4671	4464	4266	4077	3896	3722
29	5355	5114	4885	4668	4460	4263	4074	3893	3719
30	5351	5110	4881	4664	4457	4260	4071	3890	3716

TABLE of Logistical Logarithms.

	17	18	19	20	21	22	23	24	25
	1020	1080	1140	1200	1260	1320	1380	1440	1500
30	5351	5110	4881	4664	4457	4260	4071	3890	3716
31	5347	5106	4877	4660	4454	4256	4068	3887	3713
32	5343	5102	4874	4657	4450	4253	4065	3884	3710
33	5339	5098	4870	4653	4447	4250	4062	3881	3708
34	5335	5094	4866	4650	4444	4247	4059	3878	3705
35	5331	5090	4863	4646	4440	4244	4055	3875	3702
36	5326	5086	4859	4643	4437	4240	4052	3872	3699
37	5322	5082	4855	4639	4434	4237	4049	3869	3696
38	5318	5079	4852	4636	4430	4234	4046	3866	3693
39	5314	5075	4848	4632	4427	4231	4043	3863	3691
40	5310	5071	4844	4629	4424	4228	4040	3860	3688
41	5306	5067	4841	4625	4420	4224	4037	3857	3685
42	5302	5063	4837	4622	4417	4221	4034	3855	3682
43	5298	5059	4833	4618	4414	4218	4031	3852	3679
44	5294	5055	4830	4615	4410	4215	4028	3849	3677
45	5290	5051	4826	4611	4407	4212	4025	3846	3674
46	5285	5048	4822	4608	4404	4209	4022	3843	3671
47	5281	5044	4819	4604	4400	4205	4019	3840	3668
48	5277	5040	4815	4601	4397	4202	4016	3837	3665
49	5273	5036	4811	4597	4394	4199	4013	3834	3663
50	5269	5032	4808	4594	4390	4196	4010	3831	3660
51	5265	5028	4804	4590	4387	4193	4007	3828	3657
52	5261	5025	4800	4587	4384	4189	4004	3825	3654
53	5257	5021	4797	4584	4380	4186	4001	3822	3651
54	5253	5017	4793	4580	4377	4183	3998	3820	3649
55	5249	5013	4789	4577	4374	4180	3995	3817	3646
56	5245	5009	4786	4573	4370	4177	3991	3814	3643
57	5241	5005	4782	4570	4367	4174	3988	3811	3640
58	5237	5002	4778	4566	4364	4171	3985	3808	3637
59	5233	4998	4775	4563	4361	4167	3982	3805	3635
60	5229	4994	4771	4559	4357	4164	3979	3802	3632

Table of Logistical Logarithms.

	26	27	28	29	30	31	32	33	34
	1560	1620	1680	1740	1800	1860	1920	1980	2040
0	3632	3468	3310	3158	3010	2868	2730	2596	2467
1	3629	3465	3307	3155	3008	2866	2728	2594	2465
2	3626	3463	3305	3153	3005	2863	2725	2592	2462
3	3623	3460	3302	3150	3003	2861	2723	2590	2460
4	3621	3457	3300	3148	3001	2859	2721	2588	2458
5	3618	3454	3297	3145	2998	2856	2719	2585	2456
6	3615	3452	3294	3143	2996	2854	2716	2583	2454
7	3612	3449	3292	3140	2993	2852	2714	2581	2452
8	3610	3446	3289	3138	2991	2849	2712	2579	2450
9	3607	3444	3287	3135	2989	2847	2710	2577	2448
10	3604	3441	3284	3133	2986	2845	2707	2574	2445
11	3601	3438	3282	3130	2984	2842	2705	2572	2443
12	3598	3436	3279	3128	2981	2840	2703	2570	2441
13	3596	3433	3276	3125	2979	2838	2701	2568	2439
14	3593	3431	3274	3123	2977	2835	2698	2566	2437
15	3590	3428	3271	3120	2974	2833	2696	2564	2435
16	3587	3425	3269	3118	2972	2831	2694	2561	2433
17	3585	3423	3266	3115	2969	2828	2692	2559	2431
18	3582	3420	3264	3113	2967	2826	2689	2557	2429
19	3579	3417	3261	3110	2965	2824	2687	2555	2426
20	3576	3415	3259	3108	2962	2821	2685	2553	2424
21	3574	3412	3256	3105	2960	2819	2683	2551	2422
22	3571	3409	3253	3103	2958	2817	2681	2548	2420
23	3568	3407	3251	3101	2955	2815	2678	2546	2418
24	3565	3404	3248	3098	2953	2812	2676	2544	2416
25	3563	3401	3246	3096	2950	2810	2674	2542	2414
26	3560	3399	3243	3093	2948	2808	2672	2540	2412
27	3557	3396	3241	3091	2946	2805	2669	2538	2410
28	3555	3393	3238	3088	2943	2803	2667	2535	2408
29	3552	3391	3236	3086	2941	2801	2665	2533	2405
30	3549	3388	3233	3083	2939	2798	2663	2531	2403

Table of Logistical Logarithms.

	26	27	28	29	30	31	32	33	34
	1560	1620	1680	1740	1800	1860	1920	1980	2040
30	3549	3388	3233	3083	2939	2798	2663	2531	2403
31	3546	3386	3231	3081	2936	2796	2660	2529	2401
32	3544	3383	3228	3078	2934	2794	2658	2527	2399
33	3541	3380	3225	3076	2931	2792	2656	2525	2397
34	3538	3378	3223	3073	2929	2789	2654	2522	2395
35	3535	3375	3220	3071	2927	2787	2652	2520	2393
36	3533	3372	3218	3069	2924	2785	2649	2518	2391
37	3530	3370	3215	3066	2922	2782	2647	2516	2389
38	3527	3367	3213	3064	2920	2780	2645	2514	2387
39	3525	3365	3210	3061	2917	2778	2643	2512	2384
40	3522	3362	3208	3059	2915	2775	2640	2510	2382
41	3519	3359	3205	3056	2912	2773	2638	2507	2380
42	3516	3357	3203	3054	2910	2771	2636	2505	2378
43	3514	3354	3200	3052	2908	2769	2634	2503	2376
44	3511	3351	3198	3049	2905	2766	2632	2501	2374
45	3508	3349	3195	3047	2903	2764	2629	2499	2372
46	3506	3346	3193	3044	2901	2762	2627	2497	2370
47	3503	3344	3190	3042	2898	2760	2625	2494	2368
48	3500	3341	3188	3039	2896	2757	2623	2492	2366
49	3497	3338	3185	3037	2894	2755	2621	2490	2364
50	3495	3336	3183	3034	2891	2753	2618	2488	2362
51	3492	3333	3180	3032	2889	2750	2616	2486	2359
52	3489	3331	3178	3030	2887	2748	2614	2484	2357
53	3487	3328	3175	3027	2884	2746	2612	2482	2355
54	3484	3325	3173	3025	2882	2744	2610	2480	2353
55	3481	3323	3170	3022	2880	2741	2607	2477	2351
56	3479	3320	3168	3020	2877	2739	2605	2475	2349
57	3476	3318	3165	3018	2875	2737	2603	2473	2347
58	3473	3315	3163	3015	2873	2735	2601	2471	2345
59	3471	3313	3160	3013	2870	2732	2599	2469	2343
60	3468	3310	3158	3010	2868	2730	2596	2467	2341

Table of Logistical Logarithms.

	35	36	37	38	39	40	41	42	43
	2100	2160	2220	2280	2340	2400	2460	2520	2580
0	2341	2218	2099	1984	1871	1761	1654	1549	1447
1	2339	2216	2098	1982	1869	1759	1652	1547	1445
2	2337	2214	2096	1980	1867	1757	1650	1546	1443
3	2335	2212	2094	1978	1865	1755	1648	1544	1442
4	2333	2210	2092	1976	1863	1754	1647	1542	1440
5	2331	2208	2090	1974	1862	1752	1645	1540	1438
6	2328	2206	2088	1972	1860	1750	1643	1539	1437
7	2326	2204	2086	1970	1858	1748	1641	1537	1435
8	2324	2202	2084	1968	1856	1746	1640	1535	1433
9	2322	2200	2082	1967	1854	1745	1638	1534	1432
10	2320	2198	2080	1965	1852	1743	1636	1532	1430
11	2318	2196	2078	1963	1850	1741	1634	1530	1428
12	2316	2194	2076	1961	1849	1739	1633	1528	1427
13	2314	2192	2074	1959	1847	1737	1631	1527	1425
14	2312	2190	2072	1957	1845	1736	1629	1525	1423
15	2310	2188	2070	1955	1843	1734	1627	1523	1422
16	2308	2186	2068	1953	1841	1732	1626	1522	1420
17	2306	2184	2066	1951	1839	1730	1624	1520	1418
18	2304	2182	2064	1950	1838	1728	1622	1518	1417
19	2302	2180	2062	1948	1836	1727	1620	1516	1415
20	2300	2178	2061	1946	1834	1725	1619	1515	1413
21	2298	2176	2059	1944	1832	1723	1617	1513	1412
22	2296	2174	2057	1942	1830	1721	1615	1511	1410
23	2294	2172	2055	1940	1828	1719	1613	1510	1408
24	2291	2170	2053	1938	1827	1718	1612	1508	1407
25	2289	2169	2051	1936	1825	1716	1610	1506	1405
26	2287	2167	2049	1934	1823	1714	1608	1504	1403
27	2285	2165	2047	1933	1821	1712	1606	1503	1402
28	2283	2163	2045	1931	1819	1711	1605	1501	1400
29	2281	2161	2043	1929	1817	1709	1603	1499	1398
30	2279	2159	2041	1927	1816	1707	1601	1498	1397

Table of Logistical Logarithms.

	35	36	37	38	39	40	41	42	43
	2100	2160	2220	2280	2340	2400	2460	2520	2580
30	2279	2159	2041	1927	1816	1707	1601	1498	1397
31	2277	2157	2039	1925	1814	1705	1599	1496	1395
32	2275	2155	2037	1923	1812	1703	1598	1494	1393
33	2273	2153	2035	1921	1810	1702	1596	1493	1392
34	2271	2151	2033	1919	1808	1700	1594	1491	1390
35	2269	2149	2032	1918	1806	1698	1592	1489	1388
36	2267	2147	2030	1916	1805	1696	1591	1487	1387
37	2265	2145	2028	1914	1803	1694	1589	1486	1385
38	2263	2143	2026	1912	1801	1693	1587	1484	1383
39	2261	2141	2024	1910	1799	1691	1585	1482	1382
40	2259	2139	2022	1908	1797	1689	1584	1481	1380
41	2257	2137	2020	1906	1795	1687	1582	1479	1378
42	2255	2135	2018	1904	1794	1686	1580	1477	1377
43	2253	2133	2016	1903	1792	1684	1578	1476	1375
44	2251	2131	2014	1901	1790	1682	1577	1474	1373
45	2249	2129	2012	1899	1788	1680	1575	1472	1372
46	2247	2127	2010	1897	1786	1678	1573	1470	1370
47	2245	2125	2009	1895	1785	1677	1571	1469	1368
48	2243	2123	2007	1893	1783	1675	1570	1467	1367
49	2241	2121	2005	1891	1781	1673	1568	1465	1365
50	2239	2119	2003	1889	1779	1671	1566	1464	1363
51	2237	2117	2001	1888	1777	1670	1565	1462	1362
52	2235	2115	1999	1886	1775	1668	1563	1460	1360
53	2233	2113	1997	1884	1774	1666	1561	1459	1359
54	2231	2111	1995	1882	1772	1664	1559	1457	1357
55	2229	2109	1993	1880	1770	1663	1558	1455	1355
56	2227	2107	1991	1878	1768	1661	1556	1454	1354
57	2225	2105	1989	1876	1766	1659	1554	1452	1352
58	2223	2103	1987	1875	1765	1657	1552	1450	1350
59	2220	2101	1986	1873	1763	1655	1551	1449	1349
60	2218	2099	1984	1871	1761	1654	1549	1447	1347

Table of Logistical Logarithms.

	44	45	46	47	48	49	50	51	52
	2640	2700	2760	2820	2880	2940	3000	3060	3120
0	1347	1249	1154	1061	969	880	792	706	621
1	1345	1248	1152	1059	968	878	790	704	620
2	1344	1246	1151	1057	966	877	789	703	619
3	1342	1245	1149	1056	965	875	787	702	617
4	1340	1243	1148	1054	963	874	786	700	616
5	1339	1241	1146	1053	962	872	785	699	615
6	1337	1240	1145	1051	960	871	783	697	613
7	1335	1238	1143	1050	959	869	782	696	612
8	1334	1237	1141	1048	957	868	780	694	610
9	1332	1235	1140	1047	956	866	779	693	609
10	1331	1233	1138	1045	954	865	777	692	608
11	1329	1232	1137	1044	953	863	776	690	606
12	1327	1230	1135	1042	951	862	774	689	605
13	1326	1229	1134	1041	950	860	773	687	603
14	1324	1227	1132	1039	948	859	772	686	602
15	1322	1225	1130	1037	947	857	770	685	601
16	1321	1224	1129	1036	945	856	769	683	599
17	1319	1222	1127	1034	944	855	767	682	598
18	1317	1221	1126	1033	942	853	766	680	596
19	1316	1219	1124	1031	941	852	764	679	595
20	1314	1217	1123	1030	939	850	763	678	594
21	1313	1216	1121	1028	938	849	762	676	592
22	1311	1214	1119	1027	936	847	760	675	591
23	1309	1213	1118	1025	935	846	759	673	590
24	1308	1211	1116	1024	933	844	757	672	588
25	1306	1209	1115	1022	932	843	756	670	587
26	1304	1208	1113	1021	930	841	754	669	585
27	1303	1206	1112	1019	929	840	753	668	584
28	1301	1205	1110	1018	927	838	751	666	583
29	1300	1203	1109	1016	926	837	750	665	581
30	1298	1201	1107	1015	924	835	749	663	580

Table of Logistical Logarithms.

	44	45	46	47	48	49	50	51	52
	2640	2700	2760	2820	2880	2940	3000	3060	3120
30	1298	1201	1107	1015	924	835	749	663	580
31	1296	1200	1105	1013	923	834	747	662	579
32	1295	1198	1104	1012	921	833	746	661	577
33	1293	1197	1102	1010	920	831	744	659	576
34	1291	1195	1101	1008	918	830	743	658	574
35	1290	1193	1099	1007	917	828	741	656	573
36	1288	1192	1098	1005	915	827	740	655	572
37	1287	1190	1096	1004	914	825	739	654	570
38	1285	1189	1095	1002	912	824	737	652	569
39	1283	1187	1093	1001	911	822	736	651	568
40	1282	1186	1091	999	909	821	734	649	566
41	1280	1184	1090	998	908	819	733	648	565
42	1278	1182	1088	996	906	818	731	647	563
43	1277	1181	1087	995	905	816	730	645	562
44	1275	1179	1085	993	903	815	729	644	561
45	1274	1178	1084	992	902	814	727	642	559
46	1272	1176	1082	990	900	812	726	641	558
47	1270	1174	1081	989	899	811	724	640	557
48	1269	1173	1079	987	897	809	723	638	555
49	1267	1171	1078	986	896	808	721	637	554
50	1266	1170	1076	984	894	806	720	635	552
51	1264	1168	1074	983	893	805	719	634	551
52	1262	1167	1073	981	891	803	717	633	550
53	1261	1165	1071	980	890	802	716	631	548
54	1259	1163	1070	978	888	801	714	630	547
55	1257	1162	1068	977	887	799	713	628	546
56	1256	1160	1067	975	885	798	711	627	544
57	1254	1159	1065	974	884	796	710	626	543
58	1253	1157	1064	972	883	795	709	624	541
59	1251	1156	1062	971	881	793	707	623	540
60	1249	1154	1061	969	880	792	706	621	539

Table of Logistical Logarithms.

	53	54	55	56	57	58	59
	3180	3240	3300	3360	3420	3480	3540
0	539	458	378	300	223	147	73
1	537	456	377	298	221	146	72
2	536	455	375	297	220	145	71
3	535	454	374	296	219	143	69
4	533	452	373	294	218	142	68
5	532	451	371	293	216	141	67
6	531	450	370	292	215	140	66
7	529	448	369	291	214	139	64
8	528	447	367	289	213	137	63
9	526	446	366	288	211	136	62
10	525	444	365	287	210	135	61
11	524	443	363	285	209	134	60
12	522	442	362	284	208	132	58
13	521	440	361	283	206	131	57
14	520	439	359	282	205	130	56
15	518	438	358	280	204	129	55
16	517	436	357	279	202	127	53
17	516	435	356	278	201	126	52
18	514	434	354	276	200	125	51
19	513	432	353	275	199	124	50
20	512	431	352	274	197	122	49
21	510	430	350	273	196	121	47
22	509	428	349	271	195	120	46
23	507	427	348	270	194	119	45
24	506	426	346	269	192	117	44
25	505	424	345	267	191	116	42
26	503	423	344	266	190	115	41
27	502	422	342	265	189	114	40
28	501	420	341	264	187	112	39
29	499	419	340	262	186	111	38
30	498	418	339	261	185	110	36

Table of Logistical Logarithms.

	53	54	55	56	57	58	59
	3180	3240	3300	3360	3420	3480	3540
30	498	418	339	261	185	110	36
31	497	416	337	260	184	109	35
32	495	415	336	258	182	107	34
33	494	414	335	257	181	106	33
34	493	412	333	256	180	105	31
35	491	411	332	255	179	104	30
36	490	410	331	253	177	103	29
37	489	408	329	252	176	101	28
38	487	407	328	251	175	100	27
39	486	406	327	250	174	99	25
40	484	404	326	248	172	98	24
41	483	403	324	247	171	96	23
42	482	402	323	246	170	95	22
43	480	400	322	244	169	94	21
44	479	399	320	243	167	93	19
45	478	398	319	242	166	91	18
46	476	396	318	241	165	90	17
47	475	395	316	239	163	89	16
48	474	394	315	238	162	88	15
49	472	392	314	237	161	87	13
50	471	391	313	235	160	85	12
51	470	390	311	234	158	84	11
52	468	388	310	233	157	83	10
53	467	387	309	232	156	82	8
54	466	386	307	230	155	80	7
55	464	384	306	229	153	79	6
56	463	383	305	228	152	78	5
57	462	382	304	227	151	77	4
58	460	381	302	225	150	75	2
59	459	379	301	224	148	74	1
60	458	378	300	223	147	73	0

Time of Sun-rising or Seminocturnal Arcs. Lat. 56° North.
Declination North.

Decl.	0′			10′			20′			30′			40′			50′		
°	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
0	5	56	4	5	55	4	5	54	5	5	53	6	5	52	7	5	51	6
1	5	50	8	5	49	8	5	48	8	5	47	9	5	46	10	5	45	10
2	5	44	11	5	43	11	5	42	12	5	41	12	5	40	13	5	39	13
3	5	38	13	5	37	14	5	36	13	5	35	13	5	34	13	5	33	13
4	5	32	13	5	31	13	5	30	13	5	29	13	5	28	13	5	27	13
5	5	26	12	5	25	12	5	24	11	5	23	11	5	22	10	5	21	9
6	5	20	8	5	19	8	5	18	8	5	17	4	5	16	4	5	15	4
7	5	14	0	5	12	59	5	11	57	5	10	55	5	9	53	5	8	51
8	5	7	49	5	6	47	5	5	44	5	4	42	5	3	39	5	2	36
9	5	1	34	5	0	30	4	59	27	4	58	24	4	57	20	4	56	17
10	4	55	14	4	54	10	4	53	6	4	52	1	4	50	57	4	49	53
11	4	48	48	4	47	43	4	46	37	4	45	33	4	44	27	4	43	21
12	4	42	16	4	41	10	4	40	4	4	38	58	4	37	52	4	36	45
13	4	35	37	4	34	31	4	33	22	4	32	15	4	31	7	4	30	0
14	4	28	51	4	27	42	4	26	33	4	25	24	4	24	14	4	23	5
15	4	21	55	4	20	43	4	19	30	4	18	21	4	17	10	4	15	59
16	4	14	49	4	13	37	4	12	25	4	11	12	4	10	0	4	8	47
17	4	7	33	4	6	23	4	5	13	4	4	6	4	2	46	4	1	26
18	4	0	3	3	58	47	3	57	31	3	56	14	3	54	57	3	53	40
19	3	52	21	3	51	1	3	49	41	3	48	20	3	47	0	3	45	43
20	3	44	22	3	42	52	3	41	18	3	39	43	3	38	28	3	37	14
21	3	36	4	3	34	39	3	33	14	3	31	49	3	30	24	3	28	56
22	3	27	26	3	26	0	3	24	30	3	23	0	3	21	30	3	20	0
23	3	18	27	3	16	55	3	15	20	3	13	46	3	12	11	3	10	36
24	3	8	58	3	7	22	3	5	42	3	4	2	3	2	22	3	0	42
25	2	58	58	2	57	16	2	55	30	2	53	44	2	51	59	2	50	4
26	2	48	19	2	46	29	2	44	39	2	42	43	2	40	48	2	38	53

Time of Sun-rising or Seminocturnal Arcs. Lat. 56° North.
Declination South.

Decl.	0′			10′			20′			30′			40′			50′		
°	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
0	5	56	4	5	57	2	5	58	2	5	59	2	5	59	59	6	0	59
1	6	1	59	6	2	58	6	3	58	6	4	58	6	5	56	6	6	55
2	6	7	55	6	8	54	6	9	53	6	10	53	6	11	52	6	12	52
3	6	13	52	6	14	51	6	15	51	6	16	51	6	17	50	6	18	50
4	6	19	50	6	20	50	6	21	50	6	22	50	6	23	50	6	24	50
5	6	25	50	6	26	50	6	27	50	6	28	50	6	29	50	6	30	50
6	6	31	51	6	32	52	6	33	52	6	34	53	6	35	54	6	36	54
7	6	37	55	6	38	56	6	39	57	6	40	58	6	41	59	6	43	0
8	6	44	2	6	45	4	6	46	6	6	47	8	6	48	10	6	49	12
9	6	50	14	6	51	14	6	52	17	6	53	22	6	54	24	6	55	27
10	6	56	29	6	57	32	6	58	35	6	59	39	7	0	42	7	1	46
11	7	2	49	7	3	52	7	4	56	7	6	1	7	7	4	7	8	9
12	7	9	14	7	10	19	7	11	24	7	12	30	7	13	35	7	14	40
13	7	15	46	7	16	53	7	17	59	7	19	5	7	20	12	7	21	19
14	7	22	25	7	23	33	7	24	40	7	25	48	7	26	56	7	28	5
15	7	29	12	7	30	20	7	31	29	7	32	39	7	33	48	7	34	57
16	7	36	7	7	37	18	7	38	28	7	39	39	7	40	50	7	42	2
17	7	43	13	7	44	25	7	45	38	7	46	50	7	48	4	7	49	17
18	7	50	29	7	51	43	7	52	58	7	54	12	7	55	27	7	56	42
19	7	57	58	7	59	14	8	0	30	8	1	48	8	3	5	8	4	23
20	8	5	41	8	7	0	8	8	18	8	9	38	8	10	58	8	12	19
21	8	13	40	8	15	1	8	16	23	8	17	46	8	19	10	8	20	33
22	8	21	56	8	23	21	8	24	46	8	26	12	8	27	38	8	29	5
23	8	30	33	8	32	0	8	33	28	8	35	0	8	36	30	8	38	0
24	8	39	33	8	41	6	8	42	39	8	44	13	8	45	48	8	47	23
25	8	49	0	8	50	38	8	52	16	8	53	55	8	55	36	8	57	17
26	8	58	59	9	0	43	9	2	28	9	4	13	9	6	1	9	7	49

THE END.

MVSEVM
BRITAN
NICVM